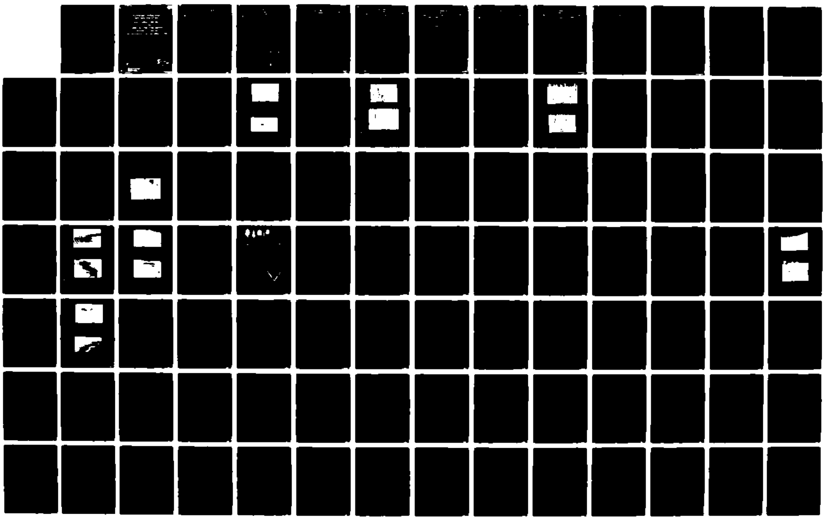
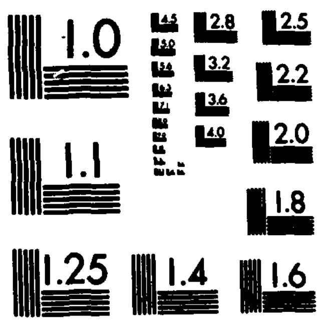
AD-A123 767 CUYAHOGA RIVER OHIO RESTORATION STUDY THIRD INTERIM PRELIMINARY FEASIBILI..(U) CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT R AGUGLIA ET AL. JUN 82 1/2

UNCLASSIFIED F/G 13/2 NL

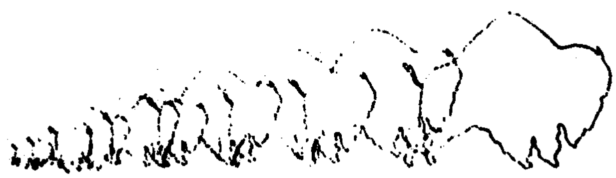



1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

AD A123767

CUYAHOGA RIVER, OHIO RESTORATION STUDY

SUPPLEMENT REPORT TO THE THIRD INTERIM PRELIMINARY FEASIBILITY REPORT ON EROSION AND SEDIMENTATION



U.S. ARMY CORPS OF ENGINEERS, BUFFALO DISTRICT
1776 NIAGARA STREET
BUFFALO, NEW YORK 14207

JUNE 1982

83 01 25 021

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO. A123767

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
Cuyahoga River, Ohio Restoration Study Supplemental Report to the Third Interim Preliminary Feasibility Report on Erosion.

5. TYPE OF REPORT & PERIOD COVERED
Interim

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
U.S. Army Engineer District, Buffalo
1776 Niagara St.
Buffalo, N.Y. 14207

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS

12. REPORT DATE
June 1982

13. NUMBER OF PAGES

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
Distribution Unlimited

15. SECURITY CLASS. (of this report)
N/A

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES
This report updates the Cayahoga River, Ohio Restoration Study third interim preliminary feasibility report on erosion and sedimentation.
Report Number AD-A102 181.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Cuyahoga River
Yellow Creek
Brandywine Creek
Erosion Control
Flood Control

erosion

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this supplement report is to document the results of the additional upland errsion studies completed subsequent to the Cuyahoga River, Ohio, restoration study third interim preliminary feasibility report(PFR) on erosion and sedimentation, November 1979. These additional studies include studies to identify and quantify indentifiable (Gully) and difuse (Sheet) nonpoint sources of erosion, and development of management programs to control erosion in the critical areas identified.

CUYAHOGA RIVER, OHIO
RESTORATION STUDY

SUPPLEMENTAL REPORT
TO THE
THIRD INTERIM PRELIMINARY FEASIBILITY REPORT
ON
EROSION AND SEDIMENTATION

TABLE OF CONTENTS

SECTION 3

SECTION 4

SECTION 5

[illegible]

[illegible]

[illegible]

TABLE OF CONTENTS (Cont'd)

TABLES (Cont'd)

v

[illegible]

PLATES

TABLE OF CONTENTS (Continued)

FIGURES

PHOTOS

TABLE OF CONTENTS (Cont'd)

ACKNOWLEDGMENTS

Many individuals, both in the Buffalo District of the Corps of Engineers and from other agencies at various levels of Government, were involved in the studies culminating in this Third Interim Preliminary Feasibility Report on Erosion and Sedimentation. Primary study team personnel of the Buffalo District who contributed significantly to the study and report preparation are:

Richard Aguglia	- Project Manager, Western Basin
John Zorich	- Chief, Western Basin
James Copley	- Civil Engineer

Special recognition is given to the many staff personnel of the Soil Conservation Service (U. S. Department of Agriculture) in the State Office at Columbus, OH, the Area Office at Medina, OH, and the Midwest Technical Service Center at Lincoln, NB, who performed the majority of the technical work associated with data collection and interpretation, preliminary designs and cost estimates and text preparation. Personnel who contributed significantly to the study are:

Robert R. Shaw	- State Conservationist
David Kile	- Assistant State Conservationist
Harvey Kananen	- Soil Conservationist, (CRRS Project Coordinato
Donald Pettit	- Soil Conservationist
Nathaniel Wilder	- Soil Conservationist
Don C. Buckloh	- Area Conservationist

A very significant contribution was made by the Ohio Department of Natural Resources in producing the OCAP maps, which locate critically eroding areas; particularly, Jim Ondecko - Chief, Land Capability Analysis.

Other agencies have contributed to this report through the preparation of supplemental reports, report material, and participation in agency workshops. The individuals involved are numerous and not easily identified.

The report itself was produced through the efforts of many other Corps personnel, including the following who contributed significantly to its preparation:

Roman Bartz	- Chief, Drafting Section
John Acker	- Drafting Section
Freda Soper	- Chief, Word Processing Center
Lillian Stryczek	- Word Processing Center
Mary Ann Schultz	- Word Processing Center
Matty Davis	- Word Processing Center
Diane Szymkowiak	- Word Processing Center
Jeanette DeZaiffe	- Word Processing Center
George Kay	- Chief, Reprographics Branch

The Buffalo District Engineer during the final phase of this Preliminary Feasibility Report was Colonel George P. Johnson, the Chief of the Engineering Division was Donald M. Liddell, and Charles E. Gilbert was Chief of the Planning Division.

Finally, the efforts of other individuals who participated in the study and report preparation but whose names have not been mentioned above, are gratefully acknowledged.

SECTION I

INTRODUCTION

PURPOSE

The purpose of this Supplemental Report is to document the results of the additional upland erosion studies completed subsequent to the Cuyahoga River, Ohio, Restoration Study Third Interim Preliminary Feasibility Report (PFR) on Erosion and Sedimentation, November 1979 (Revised April 1981). These additional studies include studies to identify and quantify identifiable (gully) and diffuse (sheet) nonpoint sources of erosion, and development of management programs to control erosion in the critical areas identified.

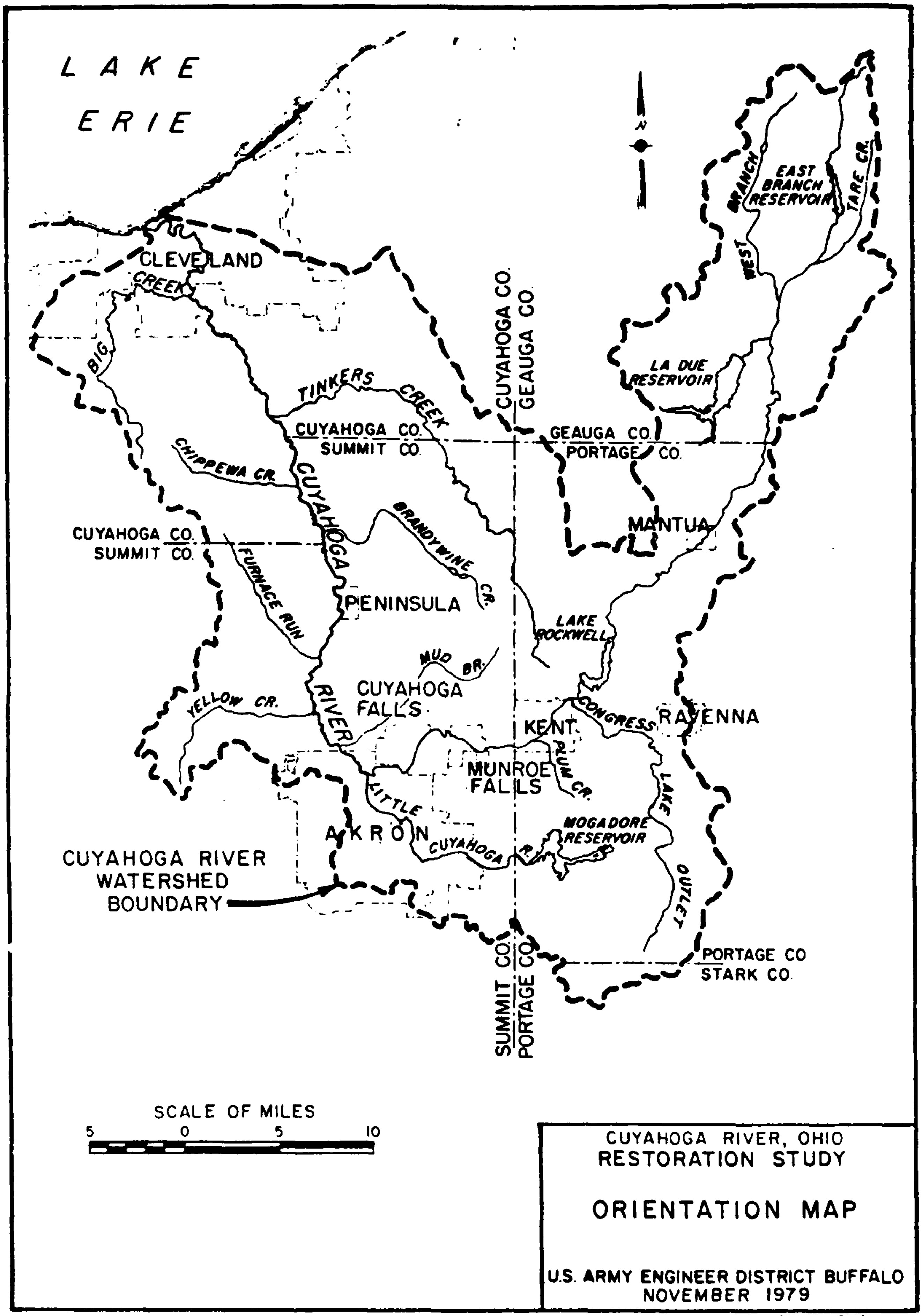
OVERVIEW OF SEDIMENT SOURCES STUDIED

The upland watershed component is concerned with gross erosion (dislodgement or detachment of soil particles) of the land surface and delivery of this sediment to a stream channel. For the purpose of this study, the sources of sediment were divided into two areas: (1) sediment produced from diffuse nonpoint sources; and (2) sediment produced from identifiable nonpoint sources. Diffuse nonpoint sources refer to the entire land surface where sheet and rill erosion occurs. Identifiable nonpoint sources refer to those areas where highly visible gully erosion on disturbed areas is taking place.

The upland watershed component study area consists of the 303 square-mile drainage area between Independence, OH, (river mile 13.8) and Old Portage, OH, (river mile 40.25) (see Figure 1). This area was identified in previous reports as the major source of sediment in the Cuyahoga River Basin.

The 303 square-mile study area was divided into seven subwatersheds for the sheet or diffuse nonpoint source erosion study. These seven subwatersheds are Mud Brook, Brandywine Creek, Tinkers Creek, Chippewa Creek, Furnace Run, Yellow Creek, and the local drainage of the Cuyahoga River. The subwatershed boundaries are shown on Plate A3-1 in Appendix I of the PFR. Studies for five of the seven subwatersheds were previously completed and the results were presented in the PFR. Results of the studies for the two remaining subwatersheds (Brandywine Creek and Yellow Creek subwatersheds) are documented in this Supplemental Report.

A separate study program was used to identify and quantify identifiable nonpoint sources of erosion (gully erosion on disturbed areas). For this study program, aerial photos from the years 1936-1937, 1951, 1969, 1974, and 1977 were extensively used to identify these identifiable nonpoint sources of erosion. In addition, identification of these source areas was confined to



CUYAHOGA RIVER, OHIO
RESTORATION STUDY

ORIENTATION MAP

U.S. ARMY ENGINEER DISTRICT BUFFALO
NOVEMBER 1979

FIGURE 1

the Standard Project Flood area for the Cuyahoga River. The reason for this decision was that the sediment produced in these source areas, due to their proximity to the river channel, is generally delivered directly to the river and causes an immediate impact on the river system.

Thirty-six identifiable nonpoint sources of erosion were previously identified by this aerial photo interpretation process and their locations are shown on Plates A3-31 and A3-32 of the PFR (also included as Plates 9 and 10 attached to this Supplemental Report :r easy reference). However, due to time constraints, the quantity of sediment produced from these source areas was not determined for the PFR. Therefore, this Supplemental Report will document the results of the subsequent studies conducted to quantify the sediment produced from these source areas.

Additional management programs were also developed to reduce the erosion that is occurring in the upland watershed component study areas studied for this Supplemental Report. Separate management programs were developed and are presented in this report to correspond to the two separate source types: (1) sediment produced from diffuse nonpoint sources (sheet and rill erosion); and (2) sediment produced from identifiable nonpoint sources (gully erosion on disturbed areas).

ORGANIZATION OF THIS REPORT

The overall organization of this Supplemental Report consists of the following sections: (1) Introduction; (2) Identification of Critically Eroding Areas; (3) Management Programs; (4) Summary and General Conclusions; and (5) Recommendations. The "Introduction" describes why this Supplemental Report was necessary and generally what the reader can expect from this report. The "Identification of Critically Eroding Areas" section presents the results of the additional upland erosion studies completed subsequent to the PFR and the "Management Programs" section describes the management programs that were developed to control erosion in the critical areas identified. The "Summary and General Conclusions" section summarizes the results of the entire erosion and sedimentation study (combined PFR and Supplemental Report). Finally the "Recommendations" section has the Final Recommendations of the entire erosion and sedimentation study.

SECTION II

IDENTIFICATION OF SOURCES OF EROSION

GENERAL

The upland watershed component is concerned with gross erosion (dislodgement or detachment of soil particles) of the land surface and delivery of this sediment to a stream channel. For the purpose of this supplemental study, the sources of sediment were divided into two areas: (1) sediment produced from diffuse nonpoint sources in the Brandywine Creek and Yellow Creek subwatersheds; and (2) sediment produced from identifiable nonpoint sources in the entire study area between Independence and Old Portate. Diffuse nonpoint sources refer to the entire land surface where sheet and rill erosion occurs. Identifiable nonpoint sources refer to those areas where highly visible gully erosion on disturbed areas is taking place. Different methods were used to identify and quantify the erosion taking place from these two nonpoint source areas. These methods are described in detail in the Preliminary Feasibility Report and briefly summarized herein.

DIFFUSE NONPOINT SOURCES OF EROSION

a. Descripton of the Study Area. The following paragraphs present a brief narrative of the conditions observed while collecting and recording the field data required to estimate sheet erosion from diffuse nonpoint sources for the two remaining subwatersheds. In addition, a brief discussion will be included on the land uses present in both of the subwatersheds. As was stated in the Preliminary Feasibility Report, land use was one of the variables recorded for each field site. The land uses that were recorded for the two subwatersheds are as follows:

Commercial/Industrial Land. Land that is primarily used for buying, selling, and processing goods and services, including sites for stores, factories, shopping centers, and industrial parks, together with necessary adjacent facilities such as underground and surface utilities, access streets and alleys, and other servicing structures, appurtenances, and measures.

Community Services Land. Land that is primarily used for schools, hospitals, churches, libraries, sewage and water treatment plants, sanitary landfills, public parking areas, and other community service facilities, together with necessary adjacent facilities such as underground and surface utilities, access streets and alleys, and other servicing structures, appurtenances, and measures.

Cropland. Land that is primarily used for the production of adapted cultivated and close-growing crops for harvest, alone or in association with sod crops. Land in fruit and nut trees, grapes, etc., is included within the cropland land use.

Homestead. Land that is primarily used for dwellings, barns, pens, corrals, gardens, and other uses in connection with operating farms.

Hayland. Land that is primarily used for the production of hay from long-term stands of adapted forage plants.

Pastureland. Land that is primarily used for the production of adapted domesticated forage plants for livestock.

Recreation Land. Land or water that is primarily used for recreation. This land use occurs on picnic areas and play areas in the Cleveland and Akron Metropolitan Parks and the Cuyahoga Valley National Recreation Area, on county, township, and city parks, Boy Scout and Girl Scout camps, church camps, private camps, ski areas, and golf courses.

Residential Land. Land that is primarily used for permanent dwellings such as houses, apartments, and housing developments, including adjacent facilities such as underground and surface utilities, access driveways and alleys, and other servicing structures, appurtenances, and measures.

Transportation Land. Land that is primarily used for highways, roads, mass transit, railroads, utility rights-of-way, airports, and other transportation facilities.

Wildlife Land. Areas in which the primary use of land or water is for fish and wildlife habitat. Wildlife lands are those areas of open shallow water, marshes, State or local designated wildlife preserves, and other areas with noncommercial woody or brushy vegetation with weedy and native grasses as its cover type. It should also be noted that wildlife land occurs in undeveloped areas of the park systems.

Woodland. Land that is primarily used to produce adapted wood crops and to provide tree cover for watershed protection, beautification, etc. (does not include farmstead and field windbreaks.) Woodland will have trees of commercial value growing and they can be of any age. It should be noted that woodland areas occur in undeveloped areas of the park systems (see Photo 1).

Other Land. Land in which the primary use is for purposes not described above. This category includes mined lands, land fills, soil spoil or storage areas, and areas being held for commercial and residential development. These areas being held for development were identified by two or more of the following site development factors: utilities already present; successional brushy and/or weedy cover type; established development on one or more boundaries; visible survey lot lines; access road areas marked or cleared; and visible advertising offering lands for development (see Photo 2).

(1) Brandywine Creek Subwatershed - Brandywine Creek subwatershed, with a drainage area of 27.2 square miles (17,408 acres), has a steep sloped topography within the lower one-third portion of its' drainage area. The remaining two-thirds of the drainage area has an undulating land surface with

Photo 1 - Woodland Area. Brandywine Creek Subwater Shed. (SCS 4/80)

Photo 2 - Land being held for development. (SCS 5/79) poor drainage conditions in the glaciated plateau. Field observatons indicated that the major areas of erosion occur on the steep forested slopes. Photos 3 and 4 illustrate this condition.

The primary land uses that occur in the subwatershed are woodland, residential land, transportation land, and other land which is being held for development, as shown on Table 1. This table was developed from the subwatershed computer printout of the collected field data. The procedure used was to expand the data collected from the areas of the subwatershed actually inventoried to a subwatershed-wide figure using the established sampling rate of 20 percent for the Brandywine Creek subwatershed. This procedure is explained in subsection b, following, and in subsection C of Appendix A (Upland Watershed Component) in the PFR. Brandywine Creek subwatershed has a high percentage of transportation land (11 percent) due to the crossing and interchanging of several different interstate and State highways within the subwatershed drainage area.

Plate 1 is the land use map for Brandywine Creek Subwatershed which was produced by the Ohio Department of Natural Resources using their Ohio Capability Analysis Program (OCAP). OCAP is a computerized information system of natural resource data such as land use, soil type, topography, water resource, etc. This natural resource data is recorded for 1.15 acre cells throughout the State of Ohio. The system also has the ability to analyze and map this information. As will be discussed in Subsection b, following, this system was used to locate areas of high potential sheet erosion.

There are three main differences between the land use information stored in the OCAP system and the land use system used for the diffuse nonpoint source erosion study. The OCAP system has 31 separate land use categories whereas the system used for this erosion study has 12 land use categories. The 31 OCAP land use categories therefore had to be merged to produce 12 categories.

The OCAP land uses for each 1.15 acre cell were determined from aerial photo interpretation whereas the system used for the erosion study used onsite field interpretation. The photo interpretation process could not differentiate between cropland, homestead, hayland, and pastureland in all instances. For example, wheat fields were identified in the OCAP system as either pastureland or grassland whereas in the land use system used for the erosion study it was classified as cropland. Therefore, the OCAP land uses of grassland, cropland, and pastureland correspond to the land uses of cropland, homestead, hayland, and pastureland for this study.

The third difference between the OCAP land use system and the land use system used in the erosion study is in the definitions of woodland, wildlife, recreation, and other land use categories. The OCAP system does not differentiate between woodland and wildlife land and defines them as the same land use (woodland). Recreation land in the OCAP system includes both developed and undeveloped land within the various park systems in the Cuyahoga River Basin. The land use system used in the erosion study classified the undeveloped land within the parks according to vegetation type (either woodland or wildlife land). Other land in the OCAP system does not include land being held for development since this could not be interpreted

Photo 3 - Forested slopes in Brandywine Creek Subwatershed.

Photo 4 - Erosion on steep forested slopes in Brandywine Creek Subwatershed. (SCS 4/78)

Table 1 - Land Use in Brandywine Subwatershed 1/

Land Use	Acreage Contained in Subwatershed	Percent Contained in Subwatershed
1. Commercial/Industrial Land	450	2
2. Community Services Land	700	4
3. Cropland	300	2
4. Homestead	0	0
5. Hayland	500	3
6. Pastureland	150	1
7. Recreation Land	300	2
8. Residential Land	3,850	22
9. Transportation Land	1,850	11
10. Wildlife Land	1,600	9
11. Woodland	5,958	34
12. Other Land	1,750	10
	17,408	100

1/ Projection of land use acreage based on SCS sampling procedures.

from aerial photos. OCAP classified this land as either woodland or grassland. In spite of these differences, the OCAP system provided a valuable tool for predicting where critical sheet erosion could occur in the study area.

(2) Yellow Creek Subwatershed - Yellow Creek subwatershed, with a drainage area of 30.7 square miles (19,648 acres), has a steep sloped topography along its main channel areas, and a rolling topography in the glaciated plateau. Field observations indicated that the major areas of erosion occur on the steep forested slopes and on residential land currently under development. The eroding residential land also normally occurs on steep slopes with woody vegetation cover. (See Photos 5 and 6).

The primary land uses that occur in the subwatershed are woodland, and residential land as shown in Table 2. Yellow Creek subwatershed has a high percentage of residential land due to its closeness to Akron and the desirability of large home lots on wooded, rolling and steep topography. This subwatershed also has the highest percentage (17 percent) of land in agricultural uses (cropland, homesteads, hayland, and pastureland) of any of the seven subwatersheds studied. Plate 2 is the OCAP land use map for this subwatershed.

Photo 5 - Erosion on recently developed residential land. (Note the unprotected soil surface.) (SCS 4/80)

Photo 6 - Steep forested slope. (SCS 4/80)

Table 2 - Land Use in Yellow Creek Subwatershed 1/

Land Use	Acreage Contained in Subwatershed	Percent Contained in Subwatershed
1. Commercial/Industrial Land	420	2
2. Community Services Land	420	2
3. Cropland	1,050	6
4. Homestead	20	0
5. Hayland	1,120	6
6. Pastureland	930	5
7. Recreation Land	200	1
8. Residential Land	6,380	32
9. Transportation Land	1,300	7
10. Wildlife Land	1,600	8
11. Woodland	4,808	24
12. Other Land	1,400	7
	19,648	100

1/ Projection of land use acreage based on SCS sampling procedures.

b. Methodologies and Approaches Used to Identify Diffuse Nonpoint Sources of Erosion. The determination of the quantity of erosion from diffuse nonpoint sources and the resultant identification of critical erosion areas was made using the Environmental Assessment Computer Program. The Environmental Assessment Computer Program was developed by the Soil Conservation Service, Midwest Technical Service Center, to evaluate impacts of proposed projects in watersheds. Items that are assessed include existing land use, crop production, sheet and rill erosion, wildlife habitat, and woodland production. The Universal Soil Loss Equation (USLE) is the basic tool used in the Environmental Assessment Computer Program to calculate the quantity of sediment produced from sheet and rill erosion. The USLE is an empirical formula, developed by the Agricultural Research Service - U.S. Department of Agriculture, that groups the numerous interrelated physical and management parameters that influence the rate of erosion into six major factors that can be expressed numerically. Although there are numerous reservations regarding the use of this equation for large basin studies, the equation is recognized as the most reliable method of quantifying potential soil movement that is currently available.

The USLE estimates the quantity of soil detached or dislodged from the land surface by raindrop action and the resultant runoff. It does not, however, measure or calculate the delivery of the eroded soil particle to a stream system. Therefore, delivery rates for each land use encountered in the study area were estimated based on field observations made while conducting the diffuse nonpoint source erosion study. These estimated delivery rates ranged from 10 percent of the quantity of soil detached from the soil surface (as estimated by the USLE) to 70 percent. For a complete discussion of the USLE and its application in this study, see the Preliminary Feasibility Report.

The Environmental Assessment Computer Program was applied to a representative sample of the land area in each subwatershed and, based on the established individual sampling rates, the results were expanded for the entire subwatershed. In this procedure, the entire 303 square mile area was used in the computer selection of the Primary Sample Units for each subwatershed (the land units that were actually inventoried). The Primary Sampling Units are randomly selected squares with 2,000 feet to a side.

Each subwatershed has its own sampling rate and can be treated as a statistically sound entity. The subwatersheds of Brandywine Creek and Yellow Creek had sampling rates of 20 percent. This means that Primary Sampling Units representing 20 percent of the land area in each subwatershed were randomly chosen to be inventoried and the results were expanded to represent the entire subwatershed. The average basin-wide sampling rate was 17.85 percent.

Once the Primary Sampling Units were established for each subwatershed, a template with a grid pattern of points was spun on each Primary Sampling Unit center point to locate the points to be evaluated in the field. This template does not give the same acreage figure per point for the two subwatersheds. The exact acreage per point can be calculated by taking the sampling rate times the total area in acres and dividing by the total number of points sampled in each subwatershed (see Table 3).

Table 3 - Subwatershed Sample Rate Data 2/

Subwatershed	Area 1/ in Acres	Square Miles	No. of Primary Sample Units	Sample Rate (percent)	Total No. of Sample Points Sampled	Corrected Acres per Pt.
Brandywine Creek	17,408	27.2	41	20	348	10
Yellow Creek	19,648	30.7	47	20	383	10.3

1/ Areas taken from USGS surveys.

2/ See Table A3.11, in Appendix A of the PFR for Sampling Rates of the Other Subwatersheds

The identification of the critical erosion problem areas was accomplished by locating areas of each subwatershed that had actual sheet and rill erosion (as determined by the USLE) greater than the tolerable soil loss value (T). The term tolerable soil loss is used to denote the maximum rate of soil erosion that will permit a high level of crop productivity to be sustained economically and indefinitely. This rate has usually been expressed in terms of average soil loss per acre per year. A special summary sheet was then prepared by subwatershed of these critical soil erosion areas by land uses. These tables appear in the next section.

The USLE will estimate the total volume of sheet and rill erosion occurring in the subwatersheds. It will not, however, locate the critical eroding areas on the landscape since only a percentage of the land surface is actually sampled. Results of the diffuse nonpoint source erosion studies indicated that critical eroding areas for each subwatershed (areas with actual sheet and rill erosion greater than the tolerable soil loss factor) could be characterized by land use in combination with certain soil types. The critical combinations of land use and soil type differs for each subwatershed, and were established from field observations. Since the Ohio Capability Analysis Program (OCAP) stores both soil type and land use data in its computer data bank, it was possible to locate potential critically eroding areas for areas not sampled. This was accomplished by having the computer locate and map the areas that had the specified combinations of land use and oil type that characterized the critically eroding areas for each subwatershed. Topographic overlap maps were then prepared for each subwatershed to allow identification of those potential critically eroding areas on the surface of the land. These maps will also be presented in the next section.

It should be noted that the land use categories for OCAP and the Environemntal Assessment Computer Program differ in several respects, as previously discussed. Therefore, in order to produce the potential critically eroding area maps for each subwatershed, some manipulation of the OCAP land use categories was required. These manipulations will also be discussed in the next section for each subwatershed. In spite of these manipulations, the

OCAP system provided a valuable tool in locating potential critically eroding areas.

c. Diffuse Nonpoint Sources of Erosion. Diffuse nonpoint sources of erosion refer to the entire land surface where sheet and rill erosion occurs. For this study the 303 square-mile drainage basin between Independence (river mile 13.8) and Old Portage (river mile 40.25) was divided into seven subwatersheds (Mud Brook, Brandywine Creek, Tinkers Creek, Chippewa Creek, Furnace Run, Yellow Creek, and the local drainage of the Cuyahoga River). Results of the studies completed for five of the seven subwatersheds were presented in the Preliminary Feasibility Report. Studies for the two remaining subwatersheds (Brandywine and Yellow Creeks) are discussed below.

The following discussion is grouped into two subsections: (a) Brandywine Creek; and (b) Yellow Creek. Each subsection will discuss the sheet and rill erosion occurring in the subwatershed under study as calculated by the Environmental Assessment Computer Program (EACP). This will be followed by a discussion on the OCAP maps produced to locate areas of potential critical erosion, including a discussion on the specific combinations of land use and soil types that were specified.

(1) Brandywine Creek Subwatershed - Table 4 presents: (1) a summary of the estimated volume of sediment produced from critical erosion areas in the Brandywine Creek subwatershed; and (2) the estimated volume of this sediment delivered to the Cuyahoga River system. This table was developed from the data generated by the Environmental Assessment Computer Program. It includes only those areas that have an existing rate of sheet erosion greater than the tolerable soil loss value. All other areas with sheet erosion rates less than the tolerable soil loss value contribute an insignificant volume of sediment and were therefore not included.

As indicated in Table 4, only 900 acres (or 5 percent of the subwatershed area) presently has a critical erosion problem. These areas produce about 29,000 tons of soil displacement per year. This represents approximately 86 percent of the total volume of soil lost from sheet and rill erosion in the entire subwatershed. Of this 29,000 tons of sediment, it is estimated that approximately 18,000 tons are delivered to the Cuyahoga River system annually.

The majority of the sediment produced from sheet and rill erosion (59 percent) occurs on woodland land use, and these areas exhibit a high rate of erosion for the same reasons as listed in the Preliminary Feasibility Report for the Furnace Run subwatershed. These reasons are summarized as follows: (1) all the soils are composed of silt and clay loams which are highly erodible; (2) the soils are on very steep slopes (ranging from 6 to 70 percent) which are subject to slipping; and (3) there is an absence of understory canopy and litter duff on the ground surface, particularly where the dominant forest species are maple, ash, and yellow-poplar. Again, it appears that the absence of the understory canopy and litter duff is the primary variable affecting the high rates of erosion. It should be noted,

Table 4 - Summary of Critical Erosion Areas Above the Tolerable Soil Loss Value - Brandywine Creek Subwatershed

Land Use	Soil	Type	Expand 1/ Acres for Subwatershed	Cover Type	Tolerable 2/ Soil Loss Value (T)	Actual 3/ Ton/Acre/ Year	Total 4/ Critical Tons for WS/Year	Sediment 5/ Delivery Rate (Present)	Quantity of Sediments Delivered to the River/Year
Woodland	CoC2	Chili Gravelly Loam	50	Woody, Comm.	3	56.0	2,800		
	ELC2	Ellsworth Silt Loam	50	Woody, Comm.	3	16.1	805		
	ELC2	Ellsworth Silt Loam	50	Woody, Comm.	3	11.7	585		
	ELC2	Ellsworth Silt Loam	50	Woody, Comm.	3	3.1	155		
	ELE2	Ellsworth Silt Loam	50	Woody, Comm.	2	9.0	450		
	ELF2	Ellsworth Silt Loam	50	Woody, Comm.	2	14.4	720		
	ELF2	Ellsworth Silt Loam	50	Woody, Comm.	2	21.4	1,070		
	LoC2	Loudonville Silt Loam	50	Woody, Comm.	3	3.1	155		
	RaC2	Rittman Silt Loam	50	Woody, Comm.	3	19.2	960		
	Rv	Rough Broken Land Clay & Silt	50	Woody, Comm.	2	17.9	895		
	Rv	Rough Broken Land Clay & Silt	50	Woody, Comm.	2	5.5	275		
	Rv	Rough Broken Land Clay & Silt	50	Woody, Comm.	2	17.1	855		
	Rv	Rough Broken Land Clay & Silt	50	Woody, Comm.	2	148.8	7,440		
			650				17,165	70	12,016
Wildlife Land	ELB	Ellsworth Silt Loam	50	Woody, Noncomm.	3	6.9	345	40	138
							270	10	27
Hayland	MgB	Mahoning Silt Loam	50	Legume, Grass	3	5.4			
Commercial Industrial Land	Rv	Rough Broken Land Clay & Silt	50	Woody & Grassy, Noncomm.	2	215.0	10,750	50	5,375
Residential Land	ELC	Ellsworth Silt Loam	50	Bare	3	6.5	325		
	Md	Made Land Sanitary Land Fill	50	Bare	1	7.2	360		
			100				685	30	206
Totals for Brandywine Creek Subwatershed			900 acres (or 5 percent of the subwatershed area) presently has a critical erosion problem 6/				29,215 tons dislodged or 86 percent of the total tons dislodged from the total subwatershed area.		17,762 tons delivered/ year

1/ Ten acres per sample point (from Table A3.11) divided by Brandywine Creek sampling rate of 20 percent and multiplied by number of data points encountered in the sample data which had the same land use, soil type, and cover type with erosion above T.

2/ The maximum rate of soil erosion expressed in tons per acre/per year that will permit a high level of crop productivity to be sustained economically and indefinitely.

3/ Existing rate of sheet and rill erosion as determined by the Universal Soil Loss Equation.

4/ Expanded acres for subwatershed mutiptlied by rate of sheet and rill erosion.

5/ Estimated delivery rate of sediment produced from sheet and rill erosion to tributary stream (from Table A3.10 of the PFR).

6/ See Plates A3-33 in Appendix I for the location of critically eroding areas in the Brandywine Creek Subwatershed.

however, that erosion rates for woodland areas in the Brandywine Creek subwatershed are less than those listed in the Preliminary Feasibility Report for Furnace Run subwatershed. The reason for this was that the forest stands in the Brandywine Creek subwatershed have a heavier litter duff layer and understory canopy. These stands were predominantly oak species which contribute a longer lasting litter duff layer. Past healment of these stands allowed a heavier understory canopy to develop in many areas (See Photo 7).

In the Brandywine Creek Subwatershed, erosion on commercial/industrial land is also a major contributor of sediment and accounts for approximately one-third of all the critical erosion in the subwatershed. Much of the commercial land is in the recently developed or development stage and the soil on the lands are generally barren. A major cause of the erosion from the recently developed lands is that once the central portion of the land is developed the perimeter is left in a barren spoiled state. This perimeter is a major source of sediment produced by erosion from the commercial/industrial lands in Brandywine Creek Subwatershed.

Plates 3 to 5 are the OCAP maps produced by ODNR which show the areas of potential critical erosion. Plate 3 locates the potential critical erosion areas on a USGS topographic map. Plates 4 and 5 show the soil type and land use for each eroding area, respectively. These maps were produced by having the OCAP computer scan its land use and soil type data base and map out those areas that had the critical combinations of land use and soil type shown in Table 5. These critical combinations were developed from the data presented in Table 4, modified to account for differences in land use catagories between the OCAP system and the Environmental Assessment Computer Program (EACP) system. In addition, cut and fill areas, gravel pits, and made land on other land use were requested in the OCAP system for all seven subwatersheds because actual field observations showed that they always produced sheet erosion above the tolerable soil loss value.

The OCAP system identified a total potential critical erosion area of 2,308 acres, or 13 percent of the total subwatershed area. These figures are significantly higher than the figures generated by the EACP system (900 acres or 5 percent of the total area). Part of this difference is due to the differences in land use classification between the two systems. For example, the EACP system identified woodland areas as a major source of sediment which is produced from sheet and rill erosion but indicated that sheet and rill erosion on wildlife land was not a significant problem. However, since the OCAP system classifies wildlife land as woodland, these wildlife areas were identified on the OCAP maps as areas of critical erosion. In addition, the ECAP system indicated that significant sheet erosion occurs in woodland areas when the dominant forest species are maple, ash, and yellow-poplar but does not occur when the dominant forest species are oak, hemlock, or white pine. Since the OCAP system used aerial photography to determine land use, a distinction could not be made between the different forest species. Therefore, the OCAP system indicates <u>potential</u> critical erosion on all woodland areas regardless of forest species. On this basis, the critically eroding areas shown on Plate 3 are undoubtedly overestimated, and should be field verified prior to implementation of any management practices.

Photo 7 - Forest floor litter duff layer provides erosion protection in Brandywine Creek Subwatershed. (SCS 5/79)

Table 5 - Critical Combinations of Land Use and Soil Type That Produce Erosion Above the Tolerable Soil Loss Value - Brandywine Creek Subwatershed 1/

Land Use	Soil Type	
Woodland Land/Wildlife Land Recreation Land	CoC2	Chili Gravelly Loam
	ELB	Ellsworth Silt Loam
	ELC2	Ellsworth Silt Loam
	ELE2	Ellsworth Silt Loam
	ELF2	Ellsworth Silt Loam
	LoC2	Loudonville Silt Loam
	RsC2	Rittman Silt Loam
	Rv	Rough Broken Land, Clay and Silt
Cropland/Pastureland/Grassland	MgB	Mahoning Silt Loam
Commercial - Industrial Land	Rv	Rough Broken Land, Clay and Silt
Residential Land	ELC	Ellsworth Silt Loam
Other Land	CF 2/	Cut and Fill
	GP 2/	Gravel Pit
	Md 2/	Made Land

1/ Critical combinations used in OCAP system to produce Plate A3-33 to A3-35 in Appendix I.

2/ Soil types and land use added based on results of studies in other subwatersheds that indicated these soils always produced erosion above the tolerable soil loss value in combination with this land use.

(2) Yellow Creek Subwatershed - Table 6 presents a summary of the critical erosion areas occurring in the Yellow Creek subwatershed. As indicated, 1,352 acres, or 7 percent of the total subwatershed area, presently has a critical erosion problem. These areas produce about 9,000 tons of soil loss per year. This represents about 63 percent of the total volume of dislodgement produced from sheet and rill erosion in the entire subwatershed. Of this 9,000 tons, it is estimated that approximately 4,000 tons of sediment are delivered to the Cuyahoga River system annually.

The amount of sheet erosion occurring in Yellow Creek subwatershed is relatively small in comparison with the sheet erosion occurring in the other subwatersheds of the study area. (See Table 8, page 20, in Summary and General Conclusions). The reasons for this are that the slope of the land in Yellow Creek subwatershed is generally flatter, especially in the upper reaches, and there is a better vegetative cover on the ground. These factors reduce the effects of the erosive force of the runoff on the soil surface and, thus, reduce the amount of erosion that is occurring. In addition, the percentage of area that is critically eroding in the Yellow Creek subwatershed is relatively small (63 percent) in comparison with the sediment dislodged from critical areas in other subwatersheds (minimum of 86 percent in Brandywine to a maximum of 97 percent in the Local Drainage subwatershed).

The majority of the sediment produced from critical sheet and rill erosion (63 percent) occurs on woodland and residential land. The eroding woodland areas and the residential areas (which are located on steep forested slopes), exhibit a high rate of erosion for the same reasons as listed for the Furnace Run subwatershed. These reasons are summarized as follows: (1) all the soils are composed of silt or gravelly loams which are highly erodible; (2) the soils are on steep slopes (ranging from 6 to 50 percent) which are subject to slipping; and (3) there is an absence of understory canopy and litter duff on the ground surface, particularly where the dominant forest species are maple, ash, and yellow-poplar. Again, it appears that the absence of understory canopy and litter duff is the primary variable affecting the high rates of erosion. It should be noted, however, that erosion rates for woodland land use in the Yellow Creek subwatershed are less than those listed for Furnace Run subwatershed. The reason for this was that the forest stands in the Yellow Creek subwatershed have a heavier litter duff layer and understory canopy. These forest stands were predominately oak species which contribute a longer lasting litter duff layer. Past treatment of these stands has allowed the development of a heavier understory canopy in many areas. It should also be noted that the presently critically eroding residential land is located in areas of new development only. It is expected that once development in these areas is completed and the landowners establish their lawns, erosion will be reduced to tolerable limits.

Cropland on the Yellow Creek Subwatershed accounts for 20 percent of the critical upland erosion occurring in the subwatershed. This is mainly because the cropland is on sloping to steep topography and conventional farming methods are practiced. The cropland is tilled in the spring and fall which loosens the soils and destroys the vegetative cover. This makes the soils susceptable to erosion, especially during the late fall and winter. Also, the channels that drain the cropland generally have a steep gradient. This

Table 6 - Summary of Critical Erosion Areas Above the Tolerable Soil Loss Value - Yellow Creek Subwatershed

Land Use	Soil	Type	Expand (1) Acres for Subwatershed	Cover Type	Tolerable (2) Soil Loss Value (T)	Actual (3) Tons/Acre/Year	Total (4) Critical Tons for WS/Year	Sediment (5) Delivery Rate (Present)	Quantity of Sediments Delivered to the River/Year
Woodland	ELE2	Ellsworth Silt Loam	52	Woody & Grassy, Comm.	2	2.4	125		
	ELF2	Ellsworth Silt Loam	52	Woody	2	15.5	806		
	ELF2	Ellsworth Silt Loam	52	Woody	2	11.1	577		
	ELF2	Ellsworth Silt Loam	52	Woody	2	9.6	499		
	GfD2	Glenford Silt Loam	52	Woody	4	4.2	218		
	LoD	Loudonville Silt Loam	52	Woody	3	4.5	234		
	RsC2	Rittman Silt Loam	52	Woody	3	4.2	218		
	RsE2	Rittman Silt Loam	52	Woody	3	8.9	463		
	RsE2	Rittman Silt Loam	52	Woody	3	7.0	364		
			468				3,504	70	2,453
Residential Land	CoD2	Chili Gravelly Loam	52	Woody Noncomm.	3	3.9	203		
	ELF2	Ellsworth Silt Loam	52	Woody & Grassy, Noncomm.	2	18.7	972		
	ELF2	Ellsworth Silt Loam	52	Woody & Grassy, Noncomm.	2	7.6	395		
	RsB	Rittman Silt Loam	52	Bare	4	4.3	224		
	RsC2	Rittman Silt Loam	52	Woody & Grassy, Noncomm.	3	3.9	203		
	RsD2	Rittman Silt Loam	52	Grassy	3	4.3	224		
			312				2,221	30	666
Cropland	WaB	Wadsworth Silt Loam	52	Wheat	4	6.7	348		
	RsC2	Rittman Silt Loam	52	Wheat	3	5.6	291		
	RsC2	Rittman Silt Loam	52	Wheat	3	3.9	203		
	RsC2	Rittman Silt Loam	52	Corn	3	18.9	983		
			208				1,825	20	365
Other Land	CF	Cut & Fill	52	Weeds	1	1.1	57		
	GbC2	Geeburg Silt Loam	52	Woody, Noncomm.	2	2.5	130		
	RsE2	Rittman Silt Loam	52	Woody, Noncomm.	3	11.7	608		
			156				795	50	398
Transportation Land	CF	Cut & Fill	52	Grassy	1	4.0	208		
	CF	Cut & Fill	52	Bare	1	3.2	166		
			104				374	50	187
Commercial-Industrial Land	RsC2	Rittman Silt Loam	52	Woody & Grassy, Noncomm.	3	3.1	161		
	RsD2	Rittman Silt Loam	52	Woody, Noncomm.	3	3.9	203		
			104				364	50	182
Totals for Yellow Creek Subwatershed			1,352 acres (or 7 percent of the subwatershed area) presently has a critical erosion problem (6)				9,083 tons dislodged or 63 percent of the total tons dislodged from the total subwatershed area		4,251 tons delivered/year

(1) 10.3 acres per sample point (from Table 3) divided by Yellow Creek sampling rate of 20 percent and multiplied by number of data points encountered in the sample data which had the same land use, soil type and cover type with erosion above T.
(2) The maximum rate of soil erosion expressed in tons per acre per year that will permit a high level of crop productivity to be sustained economically and indefinitely.
(3) Existing rate of sheet and rill erosion as determined by the Universal Soil Loss Equation.
(4) Expanded acres for subwatershed multiplied by rate of sheet and rill erosion.
(5) Estimated delivery rate of sediment produced from sheet and rill erosion to tributary stream (from Table A3.10 of the PFR).
(6) See Plates A3-36 in Appendix I for the location of critically eroding areas in the Yellow Creek Subwatershed.

steep gradient causes the soil that is dislodged to be transported directly to Yellow Creek and, eventually, to the Cuyahoga River.

Plates 6 to 8 are the OCAP maps produced by ODNR which show the areas of potential critical erosion. The specific critical combinations of land use and soil type requested in the OCAP system are shown on Table 7. These critical combinations were developed from Table 6, modified to account for differences in the land use categories between the OCAP system and the EACP system.

Table 7 - Critical Combinations of Land Use and Soil Type That Produce Erosion Above the Tolerable Soil Loss Value - Yellow Creek Subwatershed 1/

Land Use	Soil Type	
Woodland Land/Wildlife Land/Recreation Land	ELE2	Ellsworth Silt Loam
	ELF2	Ellsworth Silt Loam
	GFD2	Glenford Silt Loam
	LoD	Loudonville Silt Loam
	RsC2	Rittman Silt Loam
	RsE2	Rittman Silt Loam
Residential Land	CoD2	Chili Loam
	ELF2	Ellsworth Silt Loam
	RsB	Rittman Silt Loam
	RsC2	Rittman Silt Loam
	RsD2	Rittman Silt Loam
Cropland/Pastureland/Grassland	WaB	Wadsworth Silt Loam
	RsC2	Rittman Silt Loam
Other Land	CF	Cut and Fill
	GP 2/	Gravel Pit
	Md 2/	Made Land
	GbC2	Geeburg Silt Loam
	RsE2	Rittman Silt Loam
Transportation Land	CF	Cut and Fill
Commercial - Industrial Land	CF	Cut and Fill
	RsC2	Rittman Silt Loam
	RsD2	Rittman Silt Loam

1/ Critical combinations used in OCAP system to produce Plate 6 to 8.

2/ Soil types added based on results of studies in other subwatersheds that indicated these soils always produced erosion above the tolerable soil loss value in combination with this land use.

The OCAP system identified a total potential critical erosion area of 3,824 acres, or 19 percent of the total subwatershed area. These figures are significantly higher than the figures generated by the EACP system (1,352 acres, or 7 percent of the total area). Part of this difference is due to the differences in land use classification between the two systems. Also, the EACP system indicated that significant sheet erosion occurs in woodland areas when the dominant forest species are maple, ash, and yellow-poplar, but does not occur when the dominant forest species are oak, hemlock, or white pine. Since the OCAP system used aerial photography to determine land use, a distinction could not be made between the different forest species. Therefore, the OCAP system identifies potential critical erosion on all woodland areas regardless of forest species. In addition, the OCAP system identified all residential land on steep slopes as eroding. However, as previously stated, residential land on steep slopes has critical erosion only during the development stage. These eroding slopes eventually become stabilized as homeowners develop their lawns. Thus, the critical areas as shown on Plate 6 are undoubtedly overestimated and field verification that these areas are actually critical should be made prior to implementing any management practices.

As shown in Plate 6, potential areas of critical erosion are scattered throughout the entire subwatershed. However, there are concentrations or groupings of critical erosion areas around disturbed lands such as residential areas and roads.

d. Summary and General Conclusions. 1/ Sheet and rill erosion from diffuse nonpoint sources is a very serious problem in the seven subwatersheds of the upland watershed component study area. As shown on Table 8, approximately 928,000 tons of soil loss (or 620,000 cubic yards) is produced from sheet and rill erosion annually. Of this volume, 884,000 tons (or 590,000 cubic yards) is produced from critically eroding areas (areas which have actual sediment dislodgment above the tolerable soil loss value). These critically eroding areas occur on only 27,000 acres, or 14 percent of the total study area. All other areas with erosion rates less than the tolerable soil loss value contribute an insignificant volume (5 percent of the total volume) and can be deleted from further consideration.

As shown in Table 8, the critically eroding areas in the Local Drainage subwatershed produces the largest amount of soil loss (approximately 366,000 tons per year, or 41 percent of the total volume). This is very significant since the sediment load that it contributes to the river has an immediate impact due to its close proximity. Critically eroding areas in the Yellow Creek subwatershed contribute the smallest volume (approximately 9,000 tons per year, or 1 percent of the total volume) and are insignificant in terms of the total erosion problem.

1/ As previously stated, this Supplemental Report documents the additional erosion studies not covered in the PFR; however, this section gives Summary and General Conclusions for all the sheet erosion studies conducted for the Third Interim Study.

Table 8 - Summary of Total Soil Dislodged Sediment vs. Total Soil Dislodged From Critical Areas for Each Subwatershed 1/

Subwatershed	Total Tons of Soil Dislodged/ Year	Total Sub-watershed Acreage	Total Tons of Soil Dis-lodged from Critical Areas/Year	Total Critical Area Acreage
Mud Brook	60,871	18,752	57,317	1,395
Tinkers Creek	173,098	54,784	160,499	5,750
Chippewa Creek	88,607	11,328	85,719	1,804
Furnace Run	180,507	11,328	175,341	2,583
Local Drainage	376,035	60,672	366,213	12,922
Brandywine Creek	33,916	17,408	29,215	900
Yellow Creek	14,488	19,648	9,083	1,352
Total Area	927,522	193,920	884,387 3/	26,706
	(say 928,000 tons or 620,000 cy/yr) 2/	(say 194,000)	(say 884,000 4/ tons or 590,000 cy/yr) 2/	(say 27,000 acres 5/

1/ Critical areas are defined as those areas which have actual sediment dislodgement above the tolerable soil loss value.

2/ Assumed unit weight of 110 lbs. per cubic foot.

3/ Of this 885,000 tons of soil dislodged (590,000 cy) it is estimated that 551,000 tons (or 368,000 cy) is delivered to the Cuyahoga River system annually.

4/ 95 percent of the total soil dislodged.

5/ 14 percent of the total area acreage.

It is estimated that of the 884,000 tons of soil loss produced from critically eroding areas, 551,000 tons (or 361,000 cubic yards) is delivered to the Cuyahoga River system annually (see Table 9). In addition, because only the smaller suspended soil particles reach the river system, it is estimated that 100 percent of this volume reaches Cleveland Harbor. By comparing this volume of sediment delivered to the river system with the 860,000 cubic yards of sediment annually dredged from Cleveland Harbor, it can be concluded that the seven subwatersheds studied account for 43 percent of the total volume of sediment dredged. Therefore, in order to significantly reduce dredging costs at Cleveland Harbor, an effective erosion control program must be implemented on the critically eroding areas in these seven subwatersheds.

Plates A3-10 to A3-30 in the Preliminary Feasibility Report and Plates 3 to 8 in this Supplemental Report are the OCAP maps produced by ODNR which show the location of potential critically eroding areas in the seven subwatersheds studied. These plates are grouped into sets of three (one set per subwatershed). The first plate of each set locates the potential critical eroson areas on a USGS topographic map. The next two plates of each set show the soil type and land use for each eroding area, respectively.

The OCAP maps were produced by having the OCAP computer scan its land use and soil type data base and map out those areas that had the combinations of land use and soil type that characterized the critical erosion areas. These critical combinations were formulated from the data developed from the diffuse nonpoint source erosion study, and are different for each subwatershed. It should be noted, however, that due to the differences in land use categories between the OCAP system and the EACP system (the system used in the erosion study), some modifications were required. These modifications were previously discussed in the Preliminary Feasibility Report and this Supplemental Report.

The OCAP system identified a total potential critical erosion area of approximately 37,000 acres, or 19 percent of the total area for the seven subwatersheds studied. Thes figures are slightly higher than the figures generated by the EACP system (27,000 acres or 14 percent of the total area). This difference is due to the differences in land use classifications between the two systems and because other variables (such as tree species) which were also important in characterizing critically eroding areas are not included in the OCAP computer data base. Therefore, the OCAP maps should be interpreted as potential areas of critical erosion only. Actual critical areas should be identified by field verification of the potential areas shown on the maps.

Table 9 presents a summary of the sheet and rill erosion occurring on critical eroding areas in the seven subwatersheds studied by land use. As indicated, the majority of the dislodgement (66 percent) occurs on woodland land use, primarily in the Furnace Run and local drainage subwatersheds. These areas exhibit a high rate of erosion for the following reasons: (1) all the soils that are eroding are composed of silt and clay loams which are highly erodible; (2) the soils are on very steep slopes which are subject to slipping; and (3) there is an absence of understory canopy and litter duff on the ground surface particularly where the dominant forest species are maple, ash, and yellow-poplar. It appears that the lack of understory canopy and

Table 9 - Summary of Critical Erosion Areas by Land Use 1/

Land Use	Total Acreage of Critically Eroding Area in Each Category	Total Site Dislodged from Critical Areas for Each Category (tons/year)	Dislodgement in Each Category as Percentage of Total Dislodgement (percent)	Estimated Delivery Rate to Cleveland Harbor (Percent)	Delivered Tons/Year
Commercial-Industrial	1,165	26,520	3	50	13,260
Community Services	910	20,979	2	30	6,293
Cropland	958	13,975	2	20	2,795
Pastureland	206	1,383	-	10	139
Recreation Land	440	49,873	6	70	34,912
Transportation Land	351	1,936	-	50	968
Wildlife Land	1,903	43,182	5	40	17,272
Woodland	16,572	581,262	66	70	406,883
Other Land	2,404	126,267	14	50	63,134
Residential Land	1,747	18,740	2	30	5,622
Hayland	50	270	-	10	27
Total	26,706 (say 27,000)	884,387 (say 884,000)	100		551,305 (say 551,000)

1/ 14 percent of the 193,920 acres in total study area.

litter duff (which act together to protect the forest floor from erosion) is the most significant variable affecting the high rates of erosion. Other woodland areas with the same soil types and slopes were sampled which had significantly lower erosion rates. These areas had dominant forest species of either oak, hemlock, or white pine with an understory canopy and an accumulation of litter duff on the forest floor.

Because of the significant amount of sheet and rill erosion occurring in woodland areas, the U.S. Forest Service and ODNR-Division of Forestry were contacted in the summer of 1978 to obtain their views on this unique situation. Although some reservations were expressed about the accuracy of the numerical values calculated from the Universal Soil Loss Equation, it was recognized that serious erosion is occurring in the woodland area.

The Universal Soil Loss Equation (USLE), the basic tool used in the Environmental Assessment Computer Program to estimate sheet and rill erosion, is an empirical formula that groups the numerous interrelated physical and management parameters that influence the rate of erosion into six major factors that can be expressed numerically. Although research has supplied information from which at least approximate values may be obtained, selection of these values relies on a subjective evaluation of the physical conditions of the site under study by field personnel. Therefore, the figures presented in this report may be at best only relative indicators of the seriousness of the erosion problem. However, the Universal Soil Loss Equation is recognized as the most reliable method of quantifying potential soil movement that is currently available.

It should also be noted that the Universal Soil Loss Equation does not estimate the sediment loss due to wind erosion, which is of particular concern on agricultural land. However, because of the limited amount of agricultural land in the watershed (less than 10 percent in the seven subwatersheds studied for this report), and because the majority of the soil types present in the watershed are moderately cohesive soils, wind erosion is not a significant problem and was, therefore, not investigated.

IDENTIFIABLE NONPOINT SOURCES of EROSION

a. General. As previously discussed, a separate study program was used to identify and quantify the sediment produced by identifiable nonpoint sources (gully erosion on disturbed areas). For this study program, aerial photos from the years 1936-1937, 1951, 1969, 1974, and 1977 were extensively used to identify these identifiable nonpoint sources. These sites appeared on the aerial photo's, generally as steep slopes void of vegatation with visible gullying. This aerial photo interpretation process was supplemented with field observations made while collecting the field data required for the Environmental Assessment Computer Program. In addition, it was decided to hold identification of these source areas close to or within the Standard Project Flood area from the Cuyahoga River as defined in the "Flood Plain Information Report for the Cuyahoga River, Cuyahoga and Summit Counties, OH," (September 1969) by the Corps of Engineers, Buffalo District. The reason for this decision was that the sediment produced in these source areas, due to their proximity to the Cuyahoga River channel, is generally delivered directly to the river and causes an immediate impact on the river system.

Table 10 is a summary of the 36 identifiable nonpoint sources that were identified during preparation of the PFR using the aerial photo interpretation process process. (See Plate 9 and 10 for locations of these areas.) The identification number is the location code of the site to be used with the river mile stationing system. For example, Site 14-1 is at river mile 14 and Site 1. Table 10 also shows the approximate size of the site and the source type. (NOTE: Subsequent to completion of Stage 2 studies, each site was visited for the collection of field data. As a result of these field visits, the size of several sites were changed from that reported in the PFR. In addition, it was also discovered that several sites had become stable and no further erosion was occurring.)

The source types for these sites have been divided into four different land disturbances and are as follows:

- Construction related areas (highways and associated borrow and spoil areas, industrial, commercial, and residential developed areas) (see Photo 8).

- Sand and gravel pits (see Photo 9).

- Surface mining or stripping of topsoil and subsoil (see Photo 10).

- Fill areas such as sanitary landfills, industrial waste fills, and excess or surplus soil from other excavated areas (see Photo 11).

Table 10 - Summary of Identifiable Nonpoint Sources of Erosion Along the Cuyahoga River 1/ (river mile 13.8 to 40.25)

Identification No. 2/	Source Type	Approximate Size (Acres)
14-1	Construction Area	18
15-1	Filling & Dumping Area	12
15-2	Surface Mining Area	19
15-3	Sand and Gravel Pit	29
15-4	Surface Mining Area	3
16-1	Sand and Gravel Pit	50
17-1	Filling & Dumping Area	1
17-2	Construction Area	6
18-1	Surface Mining Area	25
18-2	Filling & Dumping Area	1/
18-3	Filling & Dumping Area	4
20-1	Construction Area	3/
21-1	Filling & Dumping Area	5
24-1	Surface Mining Area	36
25-1	Construction Area	60
25-2	Surface Mining Area	46
25-3	Sand and Gravel Pit	13
26-1	Filling & Dumping Area	1 4/
26-2	Construction Area	30
26-3	Construction Area	2
27-1	Construction Area	4
27-2	Construction Area	40
27-3	Construction Area	5

Table 10 - Summary of Identifiable Nonpoint Sources of Erosion Along the Cuyahoga River 1/ (river mile 13.8 to 40.25) (Cont'd)

Identification No. 2/	Source Type	Approximate Size (Acres)
27-4	Construction Area	7
27-5	Construction Area	2
28-1	Construction Area	28
31-1	Sand and Gravel Pit	6
33-1	Sand and Gravel Pit	8
34-1	Surface Mining Area	40
34-2	Sand and Gravel Pit	4
36-1	Surface Mining Area	3
36-2	Surface Mining Area	3
38-1	Filling & Dumping Area	45
40-1	Filling & Dumping Area	3/
40-2	Filling & Dumping Area	3/
40-3	Sand and Gravel Pit	32
Total		587 acres

1/ See Plates 9 and 10 for the locations of each source.

2/ Each identifiable nonpoint source is identified by two sets of numbers. The first set of numbers refers to the river mile where the source is located. The second set refers to the particular site within that river mile.

3/ Subsequent to Stage 2 studies, this site became stable and no further gully erosion is occurring.

4/ Subsequent to Stage 2 studies, 3 acres of this former 4 acre site became stable and has thus been deleted from this table.

Photo 8 - Identifiable nonpoint source of erosion: Construction Spoil Area (Identification No. 27-5), (SCS 11/78).

Photo 9 - Identifiable nonpoint source of erosion: Gravel Pit Operation (Identification No. 40-3), (SCS 3/79).

Photo 10 - Identifiable nonpoint source of erosion: Surface Mining of Topsoil (Identification No. 18-1), (SCS 7/79).

Photo 11 - Identifiable nonpoint source of erosion: Sanitary Land Fill (Identification No. 38-1), (SCS 3/79).

b. Methodologies and Approaches. This section presents methodologies and approaches used to quantify the volume of sediment produced from identifiable nonpoint sources of erosion.

As previously discussed, aerial photos were examined to identify possible sites of gully erosion within the Standard Project Flood area of the Cuyahoga River. Once identified on the aerial photographs, these sites were then visited several times in the summer of 1980 by Soil Conservation Service persons for the collection of additional data. During these site visits, however, it was discovered that not all of the eroding soil was delivered offsite to the Cuyahoga River. That is, portions of the sites actually trap internally the eroded soil and it never leaves the site. It was also discovered that all of the sites originally identified as having gully erosion present did not, in fact have gully erosion. Rather, on several of these sites, the erosion damage was a result of flood plain scour. Flood plain scour occurs on alluvium soils that are left unprotected by vegetation during major storm events when the river overflows its banks and scours the exposed landscape. The following paragraphs will discuss the determination of the sediment yield for the two different types of erosion, gully and flood plain scour. A discussion is also included on the method used to estimate that portion of the eroded soil delivered offset and that portion of soil trapped internally within the site.

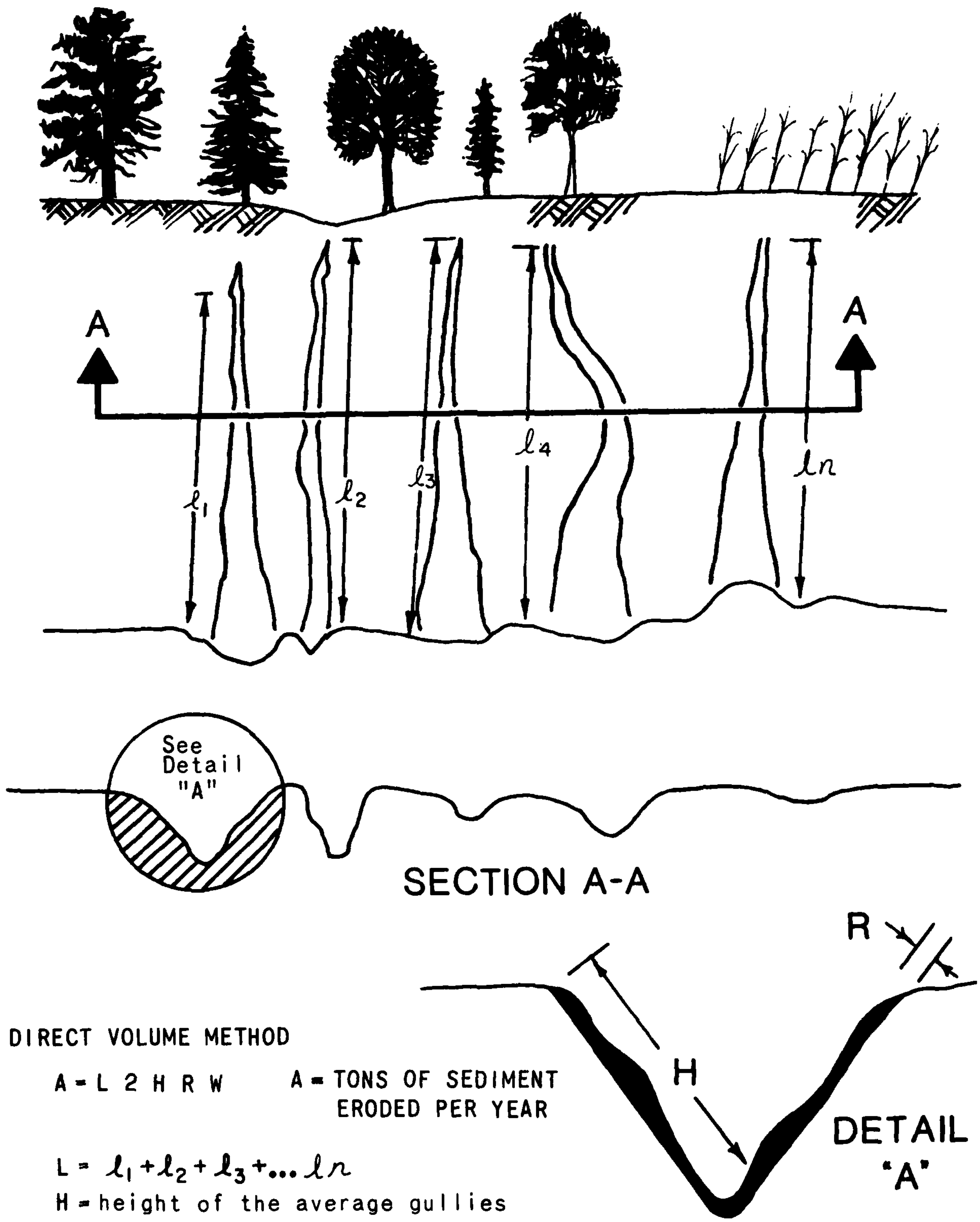
(1) Gully Erosion - The concentration of runoff over steep barren slopes encourages the formation of gullies. Gully development is associated with severe climatic events and improper land use. The gullies that are typical of the study area are generally long and narrow and form on disturbed land. Disturbance of the land has resulted in the destruction of the original soil structure and the loss of its vegetative cover. Both of these factors increase the susceptability of the soil to the erosive effect of the runoff and encourage the formation of gullies.

The volume of dislodgement produced by gully erosion on these areas was determined by the direct volume method. This method estimates the average annual amount of gross erosion in tons per year. This was done keeping in mind the high variability of gully erosion. Gully erosion is a function of annual precipitation, surface runoff, type of soil, slope of the topography, and size of the existing gully. Since several of these factors are highly variable, over time, only an average quantity, which may or may not be exceeded in any one year, could be determined.

The equation for this method is: $A = L\ 2\ H\ R\ W$, where;

A is the tons of dislodged soil material per year.

H is the average height of the gully side banks measured along the slope of those banks (see Figure 2).



DIRECT VOLUME METHOD

A = L 2 H R W A = TONS OF SEDIMENT ERODED PER YEAR

$L = l_1 + l_2 + l_3 + \ldots ln$

H = height of the average gullies

R = annual average recession rate

W = conversion factor of .055 tons/cf

CUYAHOGA RIVER, OHIO
RESTORATION STUDY

DETERMINATION OF GULLY EROSION

U.S. ARMY ENGINEER DISTRICT BUFFALO

FIGURE 2

R is the estimated average annual lateral recession rate of the gully (see Figure 2). This rate was determined in a 3 step process as follows:

Step 1 - The first step was to determine a historical rate of annual lateral recession, defined as the total recession of the gully divided by the total number of years of gully erosion. The total recession of the gully was measured directly in the field. The total number of years of gully erosion was estimated by assuming that gully erosion started when the site was initially disturbed and continued to the present time. The initial date of disturbane, in turn, was estimated from the aerial photos used in this study (aerial photos from the years 1936-1937, 1951, 1969, 1974 and 1977) and/or by talking with local residents familiar with the area.

Step 2 - The second step was to analyze several factors at the site to determine whether or not the historical rate of annual lateral recession would continue and, if not, whether the current rate was higher or lower than the historical rate. Several factors analyzed are discussed below:

- The nature of the disturbance can indicate whether or not the historical rate of annual lateral recession will continue. For example, in borrow areas, only the top layer of the soil has been disturbed. If the gully erosion has penetrated through this disturbed layer into the undisturbed soil, the current rate of annual lateral recession would be less than the historical rate. Conversely, in a spoil area where all the soil has been disturbed, it would be expected that the historical rate would continue.

- The soil profile will also indicate whether or not the historical rate of annual lateral recession will continue since different soils will erode at different rates. Therefore, if the gully has penetrated into a different soil layer, it would be expected that the current recession rate would be different from the historical rate. The current recession rate would either be higher or lower depending on whether or not the new soil layer was more or less resistent to erosion than the previous layer.

- Weathering of the soil is also an indicator of whether or not the historical rate will continue. For example, if the soils show evidence of weathering, as indicated by the dulling of the color of the soil, the current recession rate is low (less than 0.1 foot per year) since soils weather at a slow rate. Thus, if the historical rate is high, some factor has caused the rate of lateral recession to decrease in recent years.

- Occasionally, the sides of the gullies will have partially exposed rocks or boulders with clay rings. By measuring the distance between these rings, an indication of the recent recession of the gully can be obtained.

Once these factors were analyzed, an intermediate rate of annual lateral recession was established by either increasing or decreasing the historical rate based on the results of this analysis.

Step 3 - The final step was to analyze the gully after several runoff events to make final adjustments to the intermediate rate of annual lateral recession. This adjusted rate was then used in the direct volume method to estimate the volume of sediment produced by gully erosion.

L is the total length of the eroding gullies for the entire site.

W is a conversion factor of 0.055 tons/cf (assumed unit weight of soil of 110 pounds per cubic foot).

When the sites were visited for data collection, a typical set of "average" gullies were selected for analysis at each site. This set of "average" gullies were selected realizing that the results of this analysis would be expanded to estimate the soil lost by the whole site. Therefore, medium sized gullies were chosen with approximately half of the remaining gullies being larger and approximately half being smaller. The average height (H) and recession rate (R) for this set of "average" gullies were then estimated, as previously discussed. Typical heights and recession rates were 1-foot and 0.2-foot/year, respectively. Once the recession rate and height were determined for the set of "average" gullies, the total length of all the gullies at the site was measured from aerial photographs. This total length was then multiplied by the height and recession rate to obtain the volume of soil dislodged. It should be noted, however, that gully advance (head cutting) was not included in this analysis because the amount of dislodgement produced as a result of gully advance is insignificant relative to that produced by gully recession.

As previously stated, during the site visits it was discovered that not all of the eroding soil was being transported offsite. Rather, portions of the sites actually internally trap the soil and it never leaves the site. Therefore, before collecting the field data required to estimate the volume of dislodgement produced by gully erosion, the sites were divided into areas of onsite and offsite delivery. The areas of onsite delivery were identified by; the deposition of sediment on vegatation, ponding effects of surface runoff, and obvious areas of soil accumulation. The areas of offsite sediment delivery had little evidence of deposition and had a definite outlet channel to the Cuyahoga River. The direct volume method was then applied to each portion of the site in order to estimate the volume of sediment produced by gully erosion that is delivered offsite to the Cuyahoga River and that portion which is trapped internally.

(2) Flood Plain Scour - As previously discussed, during visits to each site it was discovered that all of the sites originally identified as having gully erosion present during Stage 2 studies did not, in fact, have gully erosion. Rather, on several of these sites, the erosion damage that was occurring was a result of flood plain scour. Flood plain scour occurs on alluvium soils that are unprotected by vegetative cover during major storm events when the Cuyahoga River overflows its banks and scours the exposed landscape. Disturbance of the site aggravates this problem since this disturbance destroys whatever vegetation was present and disturbs the original soil structure.

The volume of soil loss produced by flood plain scour was estimated by the surface area method. The equation for this method is T = ARW, where:

T is the tons of dislodged soil material per year.

A is the surface area of the site as measured from aerial photographs.

R is the estimated annual recession rate of the site. This rate was determined by analyzing the area around annual vegetation that was present at the site or around immovable objects, such as large boulders.

Frequently, annual vegetation becomes established in isolated areas of the site and around the perimeter of the site. This vegetation, in turn, protects the soil from flood plain scour when the river overflows its banks. Since the area immediately adjacent to this vegetation is still bare, it is still susceptable to scour and will erode when the river overflows its banks. By measuring the difference in elevation between the scoured area and the area protected by vegetation, the recession for the site can be estimated.

Immovable objects present at the site, such as large boulders, also aided in estimating the recession rate of the site. Frequently, as the area around these objects erode, soil rings will form on the rock. By measuring the distance between the soil surface and the top of the soil ring, the recession rate for the site can be estimated.

W is a conversion factor of 199.65 tons per acre-in (assumed unit weight of soil of 110 pounds per cubic foot).

Each flood plain scour site was visited after every overflow event in the summer of 1980. During each visit, several areas within each site were analyzed and recession rates were estimated for each area for that particular overflow event. An average value for the entire site for that event was then developed by averaging the individual recession rates. By adding the results for each event together for the entire year, the average annual recession rate (R) was established. Typical values of R ranged from 1/2 inch per year to 2 inches per year. This annual rate was then used in the surface area method to estimate the volume of sediment produced from flood plain scour at each site.

It should be noted that flood plain scour is highly variable from year to year. The recession rate depends on the number, duration, intensity, and abrasiveness of the flood waters. Therefore, the flow data for the Cuyahoga River at Indenpendence for 1980 was compared with the flow data of other years to determine if 1980 was an "average" flow year.

The United States Geological Survey (USGS) flow data for Independence in 1980 indicated that the average flow was 1,000 cubic feet per second. This average flow is about 25 percent higher than the long-term average of 800 cfs. However, major flow events, the events responsible for overbank flow and the resultant flood plain scour, were about average. Therefore, the annual recession rates estimated in 1980 were assumed to be the long-term average.

c. Identifiable Nonpoint Sources of Erosion Problem Areas. The following paragraphs will briefly discuss each site of identifiable nonpoint source of erosion that was originally identified on the aerial photographs during Stage 2 studies. The discussion will include a brief description of each site and the erosion problem that is occurring. The locations of these sites are shown on plates 9 and 10.

Site 14-1. This 18 acre site is a former construction area with the original vegetative cover removed by past construction activity. At one time, this site was reseeded to help reduce erosion, however this attempt failed. Thus, the bare surface of the soil is exposed directly to the surface runoff and impact of the rain. This has resulted in an increased rate of erosion and formation of gullies.

As shown in Table 11 (page 38, following the discussions of these sites), it is estimated that these gullies produce 2,100 tons of sediment per year, all of which is delivered to the Cuyahoga River. Also shown in Table 11 are the values of the various parameters used in the Direct Volume Method to estimate the volume of sediment produced by gully erosion. These values were estimated by SCS personnel when they visited the site in the summer of 1980. The height of the side bank (H) of the "average" gully evaluated at this site was 1-foot, the average annual lateral recession rate (R) was 0.05 feet per year and the total length of gullies for the entire site was 380,000 feet. Using these values in the Direct Volume Method resulted an estimate of 2,100 tons of sediment per year from gully erosion at this site.

Site 15-1. This 12-acre filling and dumping site has been in active use during the past 3 years. This activity has covered the original protective vegetative cover and has left the surface soils exposed to the erosive effects of overland flow. This activity has also destroyed the original soil structure, further increasing the soils susceptability to erosion.

When this site was visited in the summer of 1980, it was obvious that the site was experiencing flood plain scour and not gully erosion (see Photo 13, (Site 34-1), following page 36, which illustrates a typical flood plain scour site). In addition, as shown on Table 12 (page 41), it was estimated that this flood plain scour produces about 4,800 tons of sediment per year. Also shown on Table 12, are the values of the parameters used in estimating the volume of sediment from flood plain scour, with A (area) = to 12 acres and the average annual recession rate (R) equal to 2 inches per year. Multiplying these values together resulted in an estimate of 4,800 tons of sediment per year from flood plain scour at this site.

Site 15-2. This former surfaced mined area is in the flood plain adjacent to the Cuyahoga River. During mining operations, the surface soils and plant material were pushed into windrows and allowed to dry (see photo 12, following page 36). It was then loaded into trucks and sold. This operation removed the protective vegetative cover and destroyed the original soil structure. Since this site is also within the Cuyahoga River flood plain, it is subject to flood plain scour when the river overflows its banks. It is estimated that this 19-acre site generates about 3,800 tons of sediment per year from flood scour (see Table 12).

Site 15-3. This 29-acre site is a former sand, gravel, and clay pit. Although all 29 acres have gully erosion present, 24 acres of this site drains internally and has no off-site delivery of eroded sediments. This site is characteristic of a gravel pit in that most of the internal area is dug out. This forms a low area in the center causing most of the overland flow to drain internally (see Photo 15, following page 37, (Site 40-3) which illustrates a typical gravel pit site). The runoff will eventually be removed from the site by seepage through the soils or evaporation. This internal runoff causes gully erosion on the steep, barren interior slopes estimated about 5,700 tons of sediment annually, all of which is trapped internally within the site (see Table 11).

The remaining 5 acres of this site are made up of overburden material that is spoiled along the outer edges of the pit with drainage towards the Cuyahoga River. This material erodes easily because its original soil structure has been disturbed and the material is unprotected by vegetative cover. It is estimated that these 5 acres produce about 1,100 tons of sediment per year from gully erosion which is delivered to the Cuyahoga River system (see Table 11).

Site 15-4. This site is an old surfaced mined area on the main valley slopes that is no longer in use. The site is not protected by vegetative cover which leaves the soil surface exposed to the full erosive force of the overland runoff. This 3-acre site generates about 300 tons of sediment per year from gully erosion that is delivered to the Cuyahoga River (see Table 11).

Site 16-1. This 50-acre former sand and gravel pit is well above the flood plain on the upland plateau and is located at the upper edge of the steep valley slope. There is no evidence of off-site delivery of sediment produced by gully erosion from this area.

This area is typical of a sand and gravel pit with no vegetative cover and with the internal material removed. The runoff that produces gully erosion on exposed soil and side slopes drains internally and produces about 23,600 tons of sediment per year (see Table 11).

Site 17-1. This 1-acre site is a small filling and dumping area. It is located adjacent to the Cuyahoga River and is subject to flood plain scour during major storm events. This problem is exaggerated since this site is poorly protected by vegetative cover. This site generates about 100 tons of sediment per year from flood plain scour (see Table 12).

Site 17-2. This 6-acre site is a former construction area and is located across the full vertical length of the main valley slopes. Overland runoff and spring seep water flow down the steep sideslope and cause gullies to form. Previously, an attempt was made to seed the area, however, vegetation never became totally established and the area still needs erosion control measures. This site yields about 2,900 tons of sediment per year from gully erosion all of which is delivered off-site (see Table 11).

Site 18-1. This 25-acre site is a surface mined area and is located in the flood plain of the Cuyahoga River. The area is subject to frequent flooding and river scour during periods of overbank flow. Since the site has no vegetative covering (see Photo 10), this river scour accelerates the rate of erosion and generates about 5,000 tons of sediment per year from flood plain scour (see Table 12).

Site 18-2. This filling and dumping site has now been adequately protected from erosion since it was initially identified during Stage 2 studies. Thus, no gully erosion now occurs on this site.

Site 18-3. This 4-acre filling and dumping site is located in the flood plain of the Cuyahoga River. It is subject to flood plain scour during major storm events. This site also has no vegetative cover, further aggravating the serious problem. It is estimated that this site produces about 1,600 tons of sediment per year from flood plain scour (see Table 12).

Site 20-1. Subsequent to Stage 2 studies, construction activities were completed at this 9-acre site and the area was stabilized by seeding. Thus, this site presents no erosion hazard at the present time.

Site 21-1. This former filling and dumping site of 5 acres is located adjacent to the Cuyahoga River and the outlet of Chippewa Creek. Although the area has no vegetative cover, most of the area has been covered with gravel, which is highly resistent to erosion, and is used as a parking lot. However, the edges of the lot are unprotected and are eroding from the runoff off the parking lot. This unprotected area produces 1,200 tons of sediment annually from gully erosion, all of which is delivered directly to the Cuyahoga River (see Table 11).

Site 24-1. This 36-acre site is a surface mined area that is located in the flood plain of the Cuyahoga River. The site is split into approximately two equal parcels by the Cuyahoga River. Much of the area has been mined down to low flow elevations and no attempt has been made to stabilize the area by vegetative means. Major storm events overflow the area and cause flood plain scour generating about 7,200 tons of sediment per year (see Table 12).

Site 25-1. This 60-acre site is the Brandywine Ski Resort. The previously forested slopes of Brandywine valley were cleared for skiing when the resort was constructed. This activity removed the protective vegetative cover which resulted in accelerated erosion from the runoff on the barren soil surface. In addition, heavy use in the spring prevents the establishment of a new vegetative cover, which causes further erosion. It is estimated that this site produces 7,200 tons of sediment per year from gully erosion, all of which is delivered to the Cuyahoga River (see Table 11).

Site 25-2. This 46-acre site has been surface mined down to low flow elevations in several areas. The river banks have also been destroyed in several places allowing the Cuyahoga River to overflow the entire area during major storm events. This overflow flooding causes flood plain scour which generates about 9,200 tons of sediment annually (see Table 12), Site 25-3. This 13-acre former sand and gravel pit is split into two areas; an offsite delivery area of 8 acres, and an onsite delivery area of 5 acres. This site is located on the valley slopes and has very steep slopes.

This site is characteristic of gravel pits in that it has runoff that is trapped internally. This internal runoff erodes the interior slopes and forms gullies. The gravel pit operations have also disturbed the structure of the soil and destroyed the protective vegetative cover. This has exposed the soil to the full erosive force of the overland runoff resulting in an increased rate of gully erosion. It is estimated that gully erosion produces about 2,900 tons of sediment per year that is delivered offsite and 3,500 tons of sediment per year that is delivered onsite (see Table 11).

Site 26-1. This filling and dumping area is a 4-acre site located well up in the main valley slopes. It is bounded by a county road and a steep intermittent drainage channel. This site is divided into two areas; an off-site delivery area of 1 acre and an on-site delivery area of 3 acres. However, the area identified as having onsite delivery during Stage 2 studies has subsequently become stablilized and no longer erodes. This is because of the coarse nature of the fill material which is not as susceptable to erosion as silts and sands. The 1 acre eroding offsite area generates 400 tons of sediment annually from gully erosion (see Table 11).

Site 26-2. This 30-acre site is the Boston Mills Ski Resort. The previously forested slopes of the Boston Mills were cleared for resort skiing. This activity removed the protective vegetative cover and resulted in accelerated erosion from the runoff on the barren soil surface. In addition, heavy use in the spring prevents the establishment of a new vegetative cover, which causes further erosion. It is estimated that the site produces about 7,000 tons of sediment per year from gully erosion that is delivered off-site (see Table 11).

Site 26-3. This 2-acre construction site is located on the reverse slope of the Boston Mills Ski Resort (Site 26-2). The erosion is directly related to the clearing of trees and slope modification that has been done on this area for the ski resort activities. The steep slopes and lack of vegetative cover has exposed the soil surface to the full erosive force of the runoff and it is estimated that this site produces about 700 tons of sediment per year from gully erosion (see Table 11).

Site 27-1, 27-2, 27-3, 27-4, 27-5, and 28-1. These sites are Interstate Highway 80 and 271 fill, borrow, and spoil areas. They are all located within the highway construction limits and well up in elevation from the present Cuyahoga River flood plain. The areas were disturbed and all the protective vegetative cover was removed during construction activities. This aided in the formation of gullies at these sites. These sites are also all composed of silty soils with stability problems which further aggravates the gully erosion problem (see Photo 8, following page 26).

Site 27-1 is divided into areas of onsite and offsite delivery of sediment. Three of the 4 acres at site 27-1 drains internally and therefore does not deliver sediment offsite. These 3 acres produce about 800 tons of sediment per year from gully erosion (see Table 11). The remaining 83 acres generates 18,600 tons of sediment per year that is delivered to the Cuyahoga River.

Site 31-1. This 6-acre sand and gravel pit site has been inactive for some time. This site has no offsite delivery. The site generates about 1,500 tons of sediment per year from gully erosion on the internal side slopes (see Table 11).

Site 33-1. This 8-acre sand and gravel pit site, located well above the flood plain of the Cuyahoga River, has recently been abandoned. The site drains internally and generates 1,900 tons of sediment per year from gully erosion but none of this sediment leaves the site (see Table 11).

Site 34-1. This 40-acre surface mining operation site is located in the flood plain and adjacent to the Cuyahoga River. This site has been an active site of soil, sand, and gravel removal operations. These operations have left the soil barren and unprotected and easily erodable by runoff or river scour (see Photo 13). This area is subject to frequent flooding and the resulting flood plain scour generates about 16,000 tons of sediment per year (see Table 12).

Site 34-2. This 4-acre former sand and gravel pit has filled with water because there is no offsite drainage. The barren slopes around this water are exposed to surface runoff and generates 1,000 tons of sediment per year from gully erosion that does not leave the site (see Table 11). This site does not produce any sediment that is delivered offsite.

Site 36-1. This 3-acre surface mining area is located in the flood plain of the Cuyahoga River. This area is subject to frequent flooding and the resulting flood plain scour. This area is typical of surface mined areas in that all of the vegetative covering is removed which exposes the soil surface. This exposed surface is then eroded by the surface runoff or overbank flow of the Cuyahoga River. This site generates 600 tons of sediment per year from river scour (see Table 12).

Site 36-2. This 3-acre surface mining site is located well above the flood plain of the Cuyahoga River, but is adjacent to Yellow Creek. It has been included in this analysis because the gully erosion that occurs on this site is delivered directly into Yellow Creek, which in turn, transports the sediment to the Cuyahoga River.

Surface mining at this site has removed the toe of the adjacent valley slope and, due to the resultant instability of the slope, a land slip has occurred (see Photo 14). This land slip has left the valley slope void of vegetation which has aided in the formation of gullies. It is estimated that these gullies produce 35,000 tons of sediment per year that directly enters Yellow Creek (see Table 11).

Site 38-1. This active filling and dumping site is the Akron sanitary land fill and is located well above the Cuyahoga River flood plain. The 45-acre site is divided into two areas: a 20-acre area with offsite delivery, and a 25-acre area with no offsite delivery. Continuous site

Photo 12 - Site 15-2, topsoil mining operation.
(SCS 7/78)

Photo 13 - Site 34-1, flood plain scour.
(SCS 3/78)

disturbance, which is typical of sanitary land fill operations, leaves a large surface area bare. This leaves the soil unprotected against the full erosive force of the raindrop and resultant surface runoff and resluts in the formation of gullies (see Photo 11). It is estimated that the 25-acre area with no offsite delivery produces about 24,000 tons of sediment per year and the remaining 20 acre area with offsite delivery produce about 19,100 tons of sediment per year from gully erosion (see Table 11).

Site 40-1 and 40-2. Subsequent to Stage 2 studies, the former developer established vegetation on these two former filling and dumping sites and the sites are now stable. Thus, they present no erosion hazzard at the present time.

Site 40-3. This 32-acre former sand and gravel pit is located on the main valley slope and within the flood plain of the Cuyahoga River. The past gravel pit operations have prevented the establishment of vegetation. This has made the existing soil surface very vulnerable to the erosive force of the raindrop and resultant runoff and gullies have developed (see Photo 15). Some of the runoff drains internally because of the pit operations and sediment produced from gully erosion does not reach the river. This area (4 acres) produces about 2,800 tons of sediment per year from gully erosion (see Table 11). The remaining 28 acres generates about 22,800 tons of sediment per year which is delivered into the Cuyahoga River.

Photo 14 - Site 36-2, Landslide adjacent to Yellow Creek. (SCS 3/79)

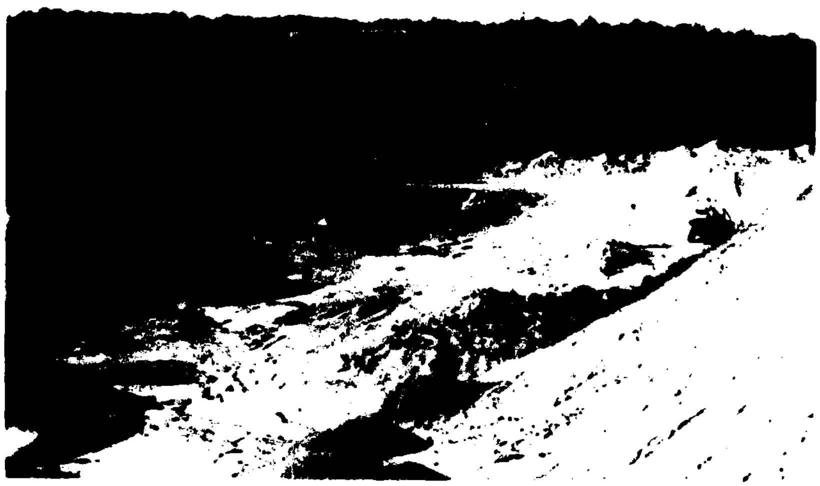


Photo 15 - Site 40-3, unprotected gravel pit. (SCS 7/77)

Table 11 - Estimated Volume of Gully Erosion From Identifiable Nonpoint Sources Along the Cuyahoga River 1/

Identification Number	Approximate Site Size (Acres): Offsite Delivery	Approximate Site Size (Acres): Onsite Delivery	Volume of Erosion Per Linear Foot of Gully (A/Lf) 2/ 3/: Average Height (H) (ft)	Avg. Annual Lateral Recession (R) (ft/yr)	Volume of Erosion per Linear Feet (A/Lf) (tons/yr/lf) 4/	Total Linear Feet of Gullies (L) (ft)	Onsite Erosion (A) 4/ (tons/yr)	Offsite Erosion (A) 4/ (tons/yr)
14-1	18	0	1.0	0.05	.0055	380,000	-	2,100
15-1 6/	-	-	-	-	-	-	-	-
15-2 6/			-	-	-	-	-	-
15-3	5	-	1.5	0.1	.0136	66,000	-	1,100
15-3	-	24	1.5	0.1	0.0165	348,000	5,700	-
15-4	3	0	3.5	0.05	0.0192	17,000	-	300
16-1	0	50	1.5	0.2	0.033	714,000	23,600	-
17-1 6/	-	-	-	-	-	-	-	-
17-2	6	0	1	0.2	0.022	130,000	-	2,900
18-1 6/	-	-	-	-	-	-	-	-
18-2 7/	-	-	-	-	-	-	-	Stabilized
18-3 6/	-	-	-	-	-	-	-	-
20-1 7/	-	-	-	-	-	-	-	Stabilized
21-1	5	0	0.8	0.1	0.0088	136,000	-	1,200
24-1 6/	-	-	-	-	-	-	-	-

Table 11 - Estimated Volume of Gully Erosion From Identifiable Nonpoint Sources Along the Cuyahoga River 1/ (Cont'd)

Identification Number	Approximate Site Size (Acres)		Volume of Erosion Per Linear Foot of Gully (A/Lf) 2/ 3/			Total Linear Feet of Gullies (L) (ft)	Onsite Erosion (A) 4/ (tons/yr)	Offsite Erosion (A) 4/ (tons/yr)
	Offsite Delivery	Onsite Delivery	Average Height (H) (ft)	Avg. Annual Lateral Recession (R) (ft/yr)	Volume of Erosion per Linear Feet (A/Lf) (tons/yr/Lf) 4/			
25-1	60	0	0.5	0.05	0.00275	2,600,000	-	7,200
25-2 6/	-	-	-	-	-	-	-	-
25-3	8	-	1.0	0.15	0.0165	173,000	-	2,900
25-3	-	5	1.0	0.30	0.033	107,000	3,500	-
26-1	1	0	0.5	0.2	0.011	40,000		400
26-1 7/	-	-	-	-	-	-	Stabilized	-
26-2	30	0	0.5	0.1	0.0055	1,280,000	-	7,000
26-3	2	0	1.0	0.3	0.033	20,000	-	700
27-1	1	-	0.5	0.1	0.0055	40,000	-	200
27-1	-	3	0.5	0.1	0.0055	140,000	800	-
27-2	40	0	2.5	0.25	0.06875	149,000	-	10,200
27-3	5	0	0.8	0.02	0.00176	125,000	-	200
27-4	7	0	0.7	0.02	0.00154	214,000	-	300
27-5	2	0	2.0	0.2	0.044	22,500	-	1,000
28-1	28	0	1.0	0.1	0.011	610,000	-	6,700
31-1	0	6	1.0	0.1	0.011	133,000	1,500	-
33-1	0	8	1.0	0.1	0.011	173,000	1,900	-

Table 11 - Estimated Volume of Gully Erosion From Identifiable Nonpoint Sources Along the Cuyahoga River 1/ (Cont'd)

Identification Number	Approximate Site Size (Acres): Offsite Delivery	Approximate Site Size (Acres): Onsite Delivery	Volume of Erosion Per Linear Foot of Gully (A/Lf) 2/ 3/: Average Height (H) (ft)	Volume of Erosion Per Linear Foot of Gully (A/Lf) 2/ 3/: Avg. Annual Lateral Recession (R) (ft/yr)	Volume of Erosion Per Linear Foot of Gully (A/Lf) 2/ 3/: Volume of Erosion per Linear Feet (A/Lf) (tons/yr/Lf) 4/	Total Linear Feet of Gullies (L) (ft)	Onsite Erosion (A) 4/ (tons/yr)	Offsite Erosion (A) 4/ (tons/yr)
34-1 6/	-	-	-	-	-	-	-	-
34-2	0	4	0.8	0.1	0.0088	113,000	1,000	-
36-1 6/		-	-	-	-	-	-	-
36-2	3	0	1	0.5	0.055	64,000	-	3,500
38-1	20	-	1	0.4	0.044	435,000		19,100
38-1	-	25	1	0.4	0.044	545,000	24,000	
40.1 7/	-	-	-	-	-	-	Stabilized	-
40-2 7/	-	-	-	-	-	-	Stabilized	-
40-3	28	-	1.5	0.3	0.0495	460,000	-	22,800
40-3	-	4	1	0.3	0.033	85,000	2,800	-
Total	272	129					64,800	89,000

1/ See Plates 9 and 10 for location of each site.
2/ Volume estimate based on dimensions of a typical "average" gully analyzed at each site.
3/ A/Lf = 2(H)(R) (0.055 tons/cf).
4/ A = (A/linear foot) X L.
6/ Flood plain scour areas were not calculated as gully erosion but were considered separately, (see Table 12).
7/ Areas is now stabilized by some action, such as seeding.
8/ Assumed unit weight of 110 pounds per cubic foot.

Table 12 - Estimated Volume of Flood Plain Scour from Identifiable Nonpoint Sources Along the Cuyahoga River 1/

Identification Number	Approximate Site Size (A) (acres)	Average Annual Recession Rate (R) (in/yr)	Volume T 2/ Sediment from Flood Plain Scour (tons/yr)
15-1	12	2	4,800
15-2	19	1	3,800
17-1	1	1/2	100
18-1	25	1	5,000
18-3	4	2	1,600
24-1	36	1	7,200
25-2	46	1	9,200
34-1	40	2	16,000
36-1	3	1	600
Total	186		48,300
			Say 48,000 (or 32,000 cy/yr cy/yr) 3/

1/ See Plates 9 and 10 for location of each site.
2/ T = AR (199.65 tons/acre-in).
3/ Assumed unit weight of 110 pounds per cubic foot.

d. Summary and General Conclusions. The identifiable nonpoint sources of erosion along the Cuyahoga River make up 32 sites involving 587 acres that are actively eroding. Originally, during Stage 2 studies, 36 sites were located on the aerial photographs but since they were first identified it was discovered that four sites and a portion of a fifth site have since stabilized. Therefore Sites 18-2, 20-1, 40-1, 40-2 and a portion of Site 26-1, will not be considered further in the analysis. The remaining sites can be divided into sites with gully erosion present and sites which are scoured by the Cuyahoga River when it overflows its banks (flood plain scour). Sites with gully erosion present can be further divided into areas with erosion involving offsite delivery of eroded sediment and areas that have erosion but none of the sediment is delivered offsite.

Gully erosion occurs in areas with steep slopes which have been disturbed by past construction activity. The steep slopes allow the overland runoff to obtain flow velocities which are destructive to the soil surface (ie., 2 to 3 feet per second). In addition, disturbance at the site destroys the protective vegetative cover, which acts as a buffer to protect the soil, and disturbs the original soil structure, further increasing the soils susceptability to erosion. When these three conditions occur at a site, gully erosion usually results.

This study identified a total of 23 sites which have gully erosion present. Of this total, 19 sites have offsite delivery of eroded sediment and it is estimated that these sites produce about 90,000 tons (60,000 cubic yards) of sediment per year. This sediment is delivered to the Cuyahoga River and accounts for about 7 percent of the 860,000 cubic yards of sediment annually dredged at Cleveland Harbor. The remaining nine sites produce about 65,000 tons (43,000 cubic yards) of sediment per year from gully erosion, but because the runoff is trapped internally within the site, this sediment does not reach the Cuyahoga River. (NOTE: Several sites have both offsite and onsite delivery of sediment and have thus been counted twice in the above discussion).

Two sites, Sites 38-1 and 40-3, produce about 41,900 tons of sediment per year from gully erosion that is delivered offsite. This represents about 47 percent of the total volume of sediment produced by gully erosion that is delivered offsite. Two other sites, Sites 16-1 and 38-1, produce about 47,600 tons of sediment per year from gully erosion, but this sediment is trapped internally within the sites and does not reach the Cuyahoga River. This represents about 73 percent of the total volume of sediment produced by gully erosion that is trapped internally. Site 38-1, the Akron sanitary land fill, is also the major producer of sediment from gully erosion, producing about 43,100 tons of sediment per year. This sediment is partly delivered offsite and partly trapped internally.

Flood plain scour occurs in areas adjacent to the Cuyahoga River which have been disturbed by past activity. This activity destroys the protective vegetative cover, which acts as a buffer to protect the soil, and disturbs the original soil structure. This allows the Cuyahoga River to scour its flood plain when it overflows its banks.

This study identified a total of nine sites which have flood plain scour present and it is estimated that these sites produce about 48,000 tons (32,000 cubic yards) of sediment per year. This represents about 4 percent of the 860,000 cubic yards of sediment annually dredged at Cleveland Harbor.

It is important to remember the difference between sediment produced by diffuse nonpoint sources (sheet and rill erosion) and sediment produced by identifiable nonpoint sources (gully erosion and flood plain scour on disturbed areas). Although the identifiable nonpoint sources are represented in the expanded erosion data for diffuse nonpoint sources, the USLE did not always evaluate these sources as severe erosion areas. That is, the estimated sheet erosion occurring in the area was below the tolerable soil loss value. The erosion that occurs here is gully erosion or flood plain scour and must be measured separately.

SECTION III

MANAGEMENT PROGRAMS

GENERAL

The purpose of this section is to present a series of management programs that would be required to reduce the erosion that is occurring in the upland watershed component study area. As previously defined, the upland watershed component study area consists of the 303 square-mile drainage area of the Cuyahoga River between Independence (river mile 13.8) and Old Portage (river mile 40.25) (see Figure 1). Sources of sediment from the upland area have been previously identified and quantified and were shown to contribute the predominate portion of the sediment load being transported by the Cuyahoga River to Cleveland Harbor.

The management programs discussed in this section are not site specific; i.e., the information presented herein will not enable the reviewer to identify a specific location and select a particular type of treatment that would be appropriate for erosion control at that location. Rather, they were developed to inform local interests of the types and extent of treatment measures that would be required to control erosion in the upland area and the magnitude of the costs which would be involved. As the management programs are implemented, they will require modifications to conform to specific field conditions. It will be the responsibility of the local interests implementing the program to identify the specific designs required for each individual site.

As previously discussed, sources of sediment derived from erosion of the upland area were divided into two source types for this study: (1) sediment produced from diffuse nonpoint sources (sheet and rill erosion); and (2) sediment produced from identifiable nonpoint sources (gully erosion and flood plain scour on disturbed areas). Separate management programs will, therefore, be presented to correspond to these separate source types.

ROLE OF THE CORPS OF ENGINEERS IN UPLAND EROSION CONTROL

As discussed in Section B of the Main Report of the Preliminary Feasibility Report - "Problem Identification," Corps of Engineers policy prohibits active participation in improvements on privately-owned land (in this instance, the Cuyahoga Valley National Recreation Area is classified as privately-owned land). Therefore, the Corps of Engineers will not implement (construct) the management programs presented in this section for controlling erosion in the upland area. Rather, the Corps looks to other units of Government, such as the National Park Service, the Soil and Water Conservation Districts, State, county, and city governments, other local agencies, and to individual landowners to implement the management programs.

The Corps views its role as a planning agency and a catalyst. In its role as a planning agency, its goals are to quantify the upland erosion problem, identify the critically eroding areas, and identify techniques that could be implemented by others to reduce erosion of the land surface. In this capacity, the Corps entered into an Interagency Agreement with the U. S. Soil Conservation Service because of their expertise in these areas. In its role as a catalyst, its goals are to stimulate an awareness in the watershed area as to the erosion problems that exist and the possible measures that can be implemented to control it. These goals were partially met with the preparation and dissemination of the Preliminary Feasibility Report and culminated with the preparation of this Supplemental Report.

GENERAL DESIGN CONSIDERATIONS

The management programs presented in this section consist of various combinations of Best Management Practices (BMP's) as detailed in the SCS "Technical Guide" and a publication entitled "Water Management and Sediment Control for Urbanizing Areas" SCS, Columbus, OH, (June 1978). BMP's are defined for this report as those practices that will prevent or reduce the sediment load generated from diffuse and identifiable nonpoint sources of erosion. They need only be implemented, however, on those areas which presently have a critical erosion problem (14 percent of the total study area for diffuse nonpoint sources).

The BMP's recommended in this report were selected because of their ability to provide erosion control. They have been thoroughly tested in various Agricultural Research Stations and by farmers and landowners in actual field use. In addition, local Soil and Water Conservation Districts have periodically conducted field days in their counties, demonstrating the implementation of these BMP's and their effectiveness in erosion control. These field days have stimulated landowners to implement these BMP's which has further established their reliability in effective erosion control.

For a complete list and description of the BMP's recommended for use in this study, see the Preliminary Feasibility Report. In addition to those listed in the Preliminary Feasibility Report, the following BMP's are recommended for treating identifiable nonpoint sources of erosion (gully erosion and flood plain scour). The description of the BMP's Critical Area Stabilization wood site preparation, tree planting, and woodland improvements, which is also discussed in the Preliminary Feasibility Report, is repeated below because of its importance and use in this report.

a. Subsurface Drain. This BMP includes the installation of a perforated conduit, such as a tile, pipe, or tubing beneath the ground surface to collect and convey subsurface water. It will be used in combination with other BMP's, such as grassed waterways and runoff diversions, to intercept and prevent groundwater and spring seep movement into wet areas; to improve the soil environment for vegetative growth; to serve as an outlet for other established subsurface drains; or to remove ponded surface water in low areas that are not drained naturally. The cost of this BMP is $1.50 per linear foot.

b. Site (Land) Grading. The purpose of this BMP is to reshape and restore land areas that have been adversely affected by past surface mining, construction, filling and dumping, and sand and gravel pit practices. This BMP will be used in conjunction with other BMP's to stabilize mined and filled areas so that the soil can support desirable vegetation. This vegetation, in turn, acts as a buffer, protecting the soil surface from the erosive force of the raindrop and resultant runoff. This BMP is one of the primary practices to be used in the stabilization of identifiable nonpoint sources of erosion. The cost for this BMP is $3,000 per acre.

c. Critical Area Stabilization (Temporary or Permanent Vegetation. Stabilization of eroding areas is accomplished by establishing temporary vegetation (wheat,oats, rye, annual grasses, etc.) or permanent vegetation (perennial grasses, shrubs, vines, etc). As previously discussed, this vegetation covering acts as a buffer, protecting the soil surface from the erosive force of the raindrop and resultant runoff. Temporary vegetation is applicable to construction sites and other sites that will have bare soil for a short period of time. Permanent vegetation is applicable to any land use and type of erosion encountered in the study area and was the principal erosion control technique selected for use. Typical cost for this BMP is approximately $300 per acre, including site preparation, seeding, fertilizing, and mulching.

d. Woodland Site Preparation. The purpose of this BMP is to prepare an existing woodland area for new tree planting (the next BMP discussed). It involves killing in place or harvesting the existing tree species in order that the newly planted tree species have adequate sunlight and space. The cost of this BMP is $50 per acre.

e. Tree Planting. This BMP involves planting tree species, such as oak, hemlock, or white pine, which have slow decaying litter duff and which promote the establishment of an understory canopy. As discussed previously, it was apparent that the absence of a litter duff layer and an understory canopy was the major contributing factor to the high erosion rates on steep, forested slopes. This condition existed when the dominant forest species were maple, ash, and tulip-poplar. A species composition change to oak, hemlock, or white pine will, therefore, retard and/or prevent further sheet erosion. Field conditions confirmed that little or no sheet erosion exists when the dominant forest species are oak, hemlock, or white pine. The cost of this BMP is approximately $150 per acre.

f. Woodland Improvement. This BMP involves selective thinning of maple, ash, and tulip-poplar species from an existing forest to allow sunlight to penetrate to the forest floor. This will encourage growth and preferred tree species such as oak, hemlock, and white pine which presently exist in the area as seedlings. If the existing forest is not thinned out, these seedlings will eventually die. The cost of this BMP is $40 per acre.

MANAGEMENT PROGRAMS FOR DIFFUSE NONPOINT SOURCES OF EROSION

The upland watershed component study area consists of the 303 square-mile drainage area between Independence, OH, (river mile 13.8) and Old Portage, OH, (river mile 40.25) (see Figure 1). The 303 square-mile upland study area was divided into seven subwatersheds for the sheet or diffuse nonpoint source erosion study. These seven subwatersheds are Mud Brook, Brandywine Creek, Tinkers Creek, Chippewa Creek, Furnace Run, Yellow Creek, and the local drainage of the Cuyahoga River. The subwatershed boundaries are shown on Plate A3-1 in Appendix I of the Preliminary Feasibility Report.

The results or conclusions of the upland erosion study for the seven subwatersheds studied, is that 14 percent of the upland area produces 95 percent of the total erosion problem. These two percentages are an average for the seven subwatersheds studied. The upland critical erosion areas varied from 5 percent to 23 percent of the total subwatershed area with the critical erosion areas contributing 63 percent to 98 percent of the total sediment load. These upland problem areas (the 14 percent average) can be identified and described by land use and soil type.

The upland potential critical erosion areas are shown on Plates A3-10 through A3-30 in Appendix I of the PFR and on Plates 3-8 attached to this report. These plates were developed using the Ohio Capability Analysis Program (OCAP) and were prepared by location of land use and soil type combinations within each subwatershed and the position where these land uses and soil types occur on the landscape. These maps locate all of the potential critical erosion areas. The development of these OCAP maps is discussed in detail in the PFR. Through the use of USGS cultural features overlay maps, or county highway maps, a specific potential critical erosion site can be located on the landscape and a route can be identified to reach it for further evaluation and possible treatment.

The separate management programs developed to control critical sheet and rill erosion within each subwatershed, as described below and shown in the Tables C3.1 to C3.5 in Appendix C of the PFR and on Tables 13 and 14 herein, were designed to treat that 14 percent of the upland critical erosion problem area. These separate management programs are groupings of the Best Management Practices (BMP's) needed to correct the critical erosion problem. Each subwatershed management program varies with the type and amount of Best Management Practices needed for specific land uses, soil types, and the existing vegetative cover conditions interacting to cause the critical erosion problem.

The following discussion presents the management programs that were developed to control critical sheet and rill erosion in Brandywine Creek and Yellow Creek subwatersheds. The management programs developed to control critical sheet and rill erosion in the other five subwatersheds of the study area were presented in the PFR and are not repeated herein.

a. Brandywine Creek Subwatershed. Brandywine Creek subwatershed has a total drainage area of 27.2 square miles (17,408 acres) and, as shown on Table 4, only about 900 acres (approximately 5 percent of the total subwatershed area) has been identified as critically eroding. The predominant land use in these critically eroding areas is woodland (650 acres). There are also four additional minor land uses: wildlife land (50 acres), hayland

Table 13 - Recommended Management Program for Brandywine Subwatershed: Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity 2/	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$	$	$
Critical Area Stabilization	Acres	300	200	60,000	3	1,800
Conservation Cropping System		0	0	0	0	0
Pasture and Hay-land Planting	Acres	50	50	2,500	1	25
Heavy Use Area Protection	Acres	400	0	0	5	0
Woodland Site Preparation	Acres	50	650	32,500	0	0
Tree Planting	Acres	150	650	97,500	1	975
Woodland Improvement	Acres	40	0	0	0	0
Runoff Diversion	Feet	1	0	0	5	0
Grassed Waterway	Acres	500	0	0	3	0
Grade Stabilization Structure	Each	2,000	-	-	5	-
Sediment Basin	Each	1,000	10	10,000	5	500
Contingencies (20 percent)	L.S.	-	-	40,500	-	-
Subtotal	-	-	-	243,000	-	3,300
Engineering and Design (10 percent)		-	-	24,300	-	-
Total	-	-	-	267,300	-	3,300

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

2/ The quantities presented are based on a 20 percent random sample of the Brandywine subwatershed (see Table 3) expanded to the entire subwatershed critical erosion area.

Table 14 - Recommended Management Program for Yellow Creek Subwatershed: Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity 2/	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	676	202,800	3	6,084
Conservation Cropping System	Acres	0	208	0	0	0
Pasture and Hay-land Planting	Acres	50	0	0	1	0
Heavy Use Area Protection	Acres	400	0	0	5	0
Woodland Site Preparation	Acres	50	468	23,400	0	0
Tree Planting	Acres	150	468	70,200	1	702
Woodland Improvement	Acres	40	0	0	0	0
Runoff Diversion	Feet	1	0	0	5	0
Grassed Waterway	Acres	500	5	2,500	3	75
Grade Stabilization Structure	Each	2,000	-	-	5	-
Sediment Basin	Each	1,000	5	5,000	5	250
Contingencies (20 percent)	L.S.	-	-	60,780	-	-
Subtotal	-	-	-	364,680	-	7,111
Engineering and Design (10 percent)	-	-	-	36,468	-	-
Total	-	-	-	401,148	-	7,111

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

2/ The quantities presented are based on a 20 percent random sample of the Yellow Creek subwatershed (see Table 3) expanded to the entire subwatershed critical erosion area.

(50 acres), commercial-industrial land (50 acres), and residential land (100 acres) experiencing critical erosion.

A management program was developed for controlling critical sheet and rill erosion in Brandywine Creek subwatershed and also for the remaining subwatersheds. It was developed by selecting Best Management Practices (BMP's) for the critically eroding areas of the subwatershed that were actually sampled (the Primary Sample Units - PSU's) and which had actual soil loss in excess of the tolerable soil loss value (T). This was calculated by the Universal Soil Loss Equation (USLE) and the resulting data put together as shown in Table 4. The individual BMP's required to treat the critically eroding areas were then multiplied by the corresponding subwatershed sampling rate (see Table 3) to arrive at the total recommended management program. For example, in the Brandywine Creek subwatershed, with a sampling rate of 20 percent, the quantities of BMP's required to control critical erosion were multiplied by 5 (20 percent) to obtain the total recommended management program shown in Table 13.

Brandywine Creek subwatershed has a total of five BMP's in the recommended management program, as shown on Table 13, to treat critical sheet and rill erosion for the five land uses shown in Table 4. Wildlife land (50 acres), commercial-industrial land (50 acres), and residential land (100 acres) will be treated for critical sheet and rill erosion with the BMP critical area stabilization. In addition, 10 temporary sediment basins will be required on residential land where steep sloped soils will be exposed for a long period of time during development. The sediment basins will no longer be needed after the sites are fully developed and vegetative cover is well established. Hayland (50 acres) will be treated with the BMP pasture and hayland planting for critical sheet and rill erosion. Woodland will be treated with 650 acres of woodland site preparation and tree planting.

The total cost to treat the critically eroding areas (5 percent of the total subwatershed) of Brandywine Creek is $267,300. The BMP costs are itemized in Table 13.

b. Yellow Creek Subwatershed. Yellow Creek subwatershed has a total drainage area of 30.7 square miles (19,648 acres) and, as shown in Table 6, only about 1,352 acres (approximately 7 percent of the total subwatershed area) has been identified as critically eroding. The three predominant land uses in these critically eroding areas are woodland (468 acres), residential land (312 acres), and cropland (208 acres). There are also three additional minor land uses: other land (156 acres), transportation land (104 acres), and commercial-industrial land (104 acres) experiencing critical erosion.

As shown in Table 14, the Yellow Creek subwatershed has a total of six BMP's in the recommended management program, to treat critical sheet and rill erosion for the six land uses shown in Table 6. Residential land (312 acres), other land (156 acres), transportation land (104 acres), and commercial-industrial land (104 acres) will be treated for critical sheet and rill erosion with the BMP critical area stabilization. In addition, five temporary sediment basins will be required on residential land where steep sloped soils will be exposed for a long period of time during development. The sediment basins will no longer be needed after the sites are fully developed and vegetative cover becomes established.

Cropland is treated with the combination of conservation cropping system (208 acres) and grassed waterways (5 acres) for critical sheet and rill erosion. Grassed waterways are required to safely dispose of runoff collected by crop rows.

Woodland will again be treated with 468 acres of woodland site preparation and tree planting.

The total cost to treat the critically eroding areas of Yellow Creek subwatershed is $401,148. The BMP costs are itemized in Table 14.

c. Summary and General Conclusion. The critical sheet and rill erosion that occurs in the 303 square-mile upland study area between Independence, OH (river mile 13.8) and Old Portage, OH, (river mile 40.25), (see Figure 1), is a major source of the sediment that arrives annually in Cleveland Harbor.

Within this area, it has ben concluded that 14 percent of the total acreage, or 27,000 acres, is producing 95 percent of the total sediment dislodged (884,000 tons per year) as shown in Table 8. These critically eroding acres (14 percent) can be successfully treated to reduce erosion to within the tolerable soil loss limits (as shown in Table A3.6 in Appendix A of the PFR) by implementing management programs (as shown in Tables C3.1 through C3.5 in Appendix C of the PFR and Tables 13 and 14 of this report) composed of various combinations of 11 Best Management Practices (BMP's). Three BMP's (critical area stabilization, woodland site preparation, and tree planting) of the 11 are the major ones recommended to control critical sheet and rill erosion in the majority of cases or sites. The total initial installation cost to treat the seven subwatersheds studied is $7,800,000, as shown in Table 15, or approximately $300 per acre.

The Best Management Practices that are recommended for the upland watershed component have long-term effects on erosion and have relatively low maintenance costs. These BMP's are of a self-liquidating nature with long-term benefits that are equal to or greater than their costs. The BMP's (agronomic, vegetative, and forestry) are simple enough that landowners can implement the practices themselves with very limited technical assistance. This will reduce the installation costs and the landowner can perform the maintenance requirements.

MANAGEMENT PROGRAMS FOR IDENTIFIABLE NONPOINT SOURCES OF EROSION

a. Management Programs. The purpose of this section is to present a series of management programs that would be required to reduce the erosion that is occurring on identifiable nonpoint sources of erosion (gully erosion and flood plain scour on disturbed areas). As previously discussed, identification of these source areas was held close to or within the Standard Project flood area of the Cuyahoga River between Independence (river mile 13.8) and Old Portage (river mile 40.25). The reason for this decision was

Table 15 - Summary of Recommended Management Programs for the Upland Watershed Component Study Area: Estimated First Cost and Annual Operation and Maintenance Cost

Subwatershed 1/	First Cost of Construction 2/	Annual Operation and Maintenance Cost 2/
	$	$
Mud Brook	325,380	5,265
Tinkers Creek	1,782,990	33,851
Chippewa Creek	632,095	12,199
Furnace Run	768,504	8,795
Local Drainage	3,671,778	35,379
Brandywine Creek	267,300	3,300
Yellow Creek	401,148	7,111
Total	7,849,195	105,900
	Say 7,800,000	Say 106,000

1/ Figures apply only to the treatment of identified critical erosion areas as shown in Tables A3.12 through A3.20 in Appendix A of the PFR and Tables 4 and 6 presented herein.
2/ November 1979 price levels.

that the sediment produced in these source areas, due to their close proximity to the Cuyahoga River, is generally delivered directly to the river and causes an immediate impact on the river system.

As previously discussed, the erosion study identified a total of 32 sites where gully erosion or flood plain scour is occurring within the study area. The locations of these 32 sites are shown on Plates 9 and 10. The study also indicated that gully erosion produces about 90,000 tons of sediment per year that is delivered to the Cuyahoga River and 65,000 tons of sediment per year that is trapped internally before it reaches the Cuyahoga River. Flood plain scour produces about 48,000 tons of sediment per year, all of which enters the river system. Of the 138,000 tons of sediment (92,000 cubic yards) produced from identifiable nonpoint sources of erosion which reaches the Cuyahoga River, it is estimated that 100 percent of this sediment is delivered to Cleveland Harbor and requires maintenance dredging. This represents about 11 percent of the 860,000 cubic yards of sediment annually dredged.

Separate management programs were developed to control gully erosion and flood plain scour on the 32 sites identified. These management programs are groupings of Best Management Practices (BMP's) need to correct the erosion problem and vary from site to site. The management program for each site are presented in Tables 16 through 47.

For all sites, the BMP critical area stabilization is required to stabilize the site and prevent future erosion. Critical area stabilization will provide a protective ground cover over the sod surface, absorbing the impact energy of the raindrop before it comes in contact with the soil and protecting the soil surface from the erosive force of the resultant runoff. In addition, in most cases, site grading is required to fill in the existing gullies, to flatten out the slope (which will prevent the overland flow from obtaining damaging flow velocities) and to prepare the area for seeding. In the few instances where site grading is not required for the entire site, that portion of the site that will not be graded only requires site preparation for seeding. The cost of this preparation is included in the cost for critical area stabilization. Also, at a few sites, grade stabilization structures have been included in the management plan. These structures will be installed in existing drainage channels at the sites and will convey runoff water through differentials in elevation without downcutting the drainage channel. It should be noted that management programs have been developed to control sediment produced by gully erosion for areas which have both offsite delivery and onsite delivery. Although the sediment produced by gully erosion that is trapped internally within the site does not impact on the river systems, it still represents a loss of a natural resource (ie., soil). Therefore, management programs have been developed to prevent this loss.

Since the majority of the management programs that were developed to control gully erosion and flood plain scour on the 32 identified sites in the study area are composed of combinations of the above discussed BMP's, a separate discussion of the management program for each site has not been provided. Rather, the reviewer is referred to Tables 16 through 47 for the specific management program for each individual site. However, several sites, Sites 17-2, 26-2, 27-2, 38-a, and 40-3, require additional BMP's to stabilize the site and control erosion over and above the BMP's discussed above. The additional BMP's and the need for them are discussed below.

Site 17-2. This 6 acre site was originally used as a highway borrow area. Construction activity removed all the protective vegetation from the surface and the overland runoff and spring seep water which flow down the steep side slopes caused gullies to form. Previously, an attempt was made to seed the area, however, vegetation never became totally established and the area still needs erosion control measures.

The management program developed to control gully erosion at this site includes (see Table 23, page 64); 6 acres of critical area stabilization; 6 acres of site grading; a grade stabilization structure; and 1,000 feet of subsurface drains.

Subsurface drains are required to drain the spring seep. This spring seep procedures a constant flow on the soil surface and prevents the establishment of vegetation. The subsurface drains will intercept this flow and transport it to the grade stabilization structure. The grade stabilization structure will also stabilize the mouth of the existing drainage outlet, preventing "down-cutting" in the drainage channel.

Site grading (6 acres) is required to flatten out the steep slopes which, in turn, will prevent the surface runoff from obtaining eroding velocities and to fill in the existing gullies. Critical area stabilization (6 acres) will provide a protective ground cover for the soil surface, absorbing the impact energy of the raindrop before it comes in contact with the soil surface and protecting the soil from the erosive force of the resultant runoff.

The total cost for the management program at this site is approximately $31,000 (November 1979 price levels).

Site 26-2. This 30-acre site is the Boston Mills ski resort. The previously forested slopes were cleared for resort skiing. This activity removed the protective vegetative cover and resulted in accelerated erosion from the runoff on the barren soil surface. In addition, heavy use in the spring prevents the establishment of a new vegetative cover, which causes further erosion.

The management program developed to control gully erosion at this site includes (see Table 32, page 73): critical area stabilization (30 acres); and runoff diversions (2,000 feet).

Runoff diversions are required to divert the runoff to the existing drainage outlet channel on the sides of the slope. This will reduce both the velocities and the volume of the runoff down the slopes. This enables the vegetation to establish itself between the diversion channels. Once the vegetation establishes itself between the diversion channels, the diversion channels can be filled and vegetation established on these areas. The cost to fill the diversion channels and seed the area is included in the unit cost for this BMP.

Critical area stabilization will provide a protective ground cover over the soil surface, absorbing the impact energy of the raindrop before it comes in contact with the soil and protecting the soil surface from the erosive force of the resultant runoff. The cost for regrading the gullies is included in the unit cost for this BMP.

The total cost for the management program at this site is approximately $44,000 (November 1979 price levels).

Site 27-2. This (40-acre) site is one of several borrow and spoil areas used for the construction of sites that are Interstate Highways 80 and 271. This site is located between the two highways and is a spoil area. Long steep barren slopes with extensive gullying is characteristic of this site. Seeding was attempted in the past, however, due to the steep slopes and resulting erosive velocities obtained by the runoff, the vegetation was not able to establish itself.

The management program developed to control gully erosion at this site includes (see Table 35, page 76); 40 acres of critical area stabilization; 40 acres of site grading; 5,500 feet of runoff diversion channels; 2 acres of grassed waterways; 12 grade stabilization structures and 2,000 feet of subsurface drains.

Subsurface drains (2,000 feet) are required to drain the spring seep. This spring seep produces a constant flow on the soil surface and prevents the establishment of vegetation. The subsuface drains will intercept this flow and transport it to the grade stabilization structures. The 12 grade stabilization structures along with the grassed waterways will form an integrated system of drainage which will transport the runoff through variations in elevation at the site. The grassed waterways (2 acres) were designed so that the flow velocities of the collected runoff are nonerosive.

Runoff diversions (5,500 feet) will transport overland runoff diagonally across the slope, preventing excessive and erosive flow velocities from forming. These runoff diversions will deliver the runoff to the grassed waterways.

Site Grading (40 acres) is required to slightly flatten out the steep slopes and to fill in the existing gullies. However, this site is too long and steep to make any overall major change in the slope.

Critical area stabilization (40 acres) will provide a protective ground cover over the soil surface, absorbing the impact energy of the raindrop before it comes in contact with the soil and protecting the soil surface from the erosive force of the resultant runoff.

The total cost for the management program at this site is approximately $218,000 (November 1979 price levels).

Site 38-1. This 45 acre site is the Akron sanitary land fill which is still in active use. Continuous site disturbance, which is typical of sanitary land fill operations, leaves a large area of this site bare. Because the soil is unprotected, it is exposed to the full impact force of the raindrop and resultant runoff and gullies have developed (see Photo 11).

The management program developed to control gully erosion at this site includes (see Table 46, page 87): 45 acres of critical area stabilization; 20 acres of site grading; one grade stabilization structure; and two temporary sediment basins.

Site grading (20 acres) is required to flatten out the steep slopes around the perimeter of the site (which will prevent the surface runoff from obtaining eroding velocities and to fill in the existing gullies. However, because 25 acres of this site are now fairly flat, only site preparation for seeding will be required for this 25-acre area. The cost for this site preparation is included in the unit cost for critical area.

Critical area stabilization (45 acres) will provide a protective ground cover over the soil surface, absorbing the impact energy of the raindrop before it comes in contact with the soil and protecting the soil surface from the erosive force of the resultant runoff. However, because this site is currently in active use, only those areas for which land fill operations have been completed can be stabilized at the present time. Therefore, two temporary sediment basins have been included in the management plan to prevent the sediment eroding off these areas in active use from entering the river system. Once land fill operations have been completed, the remaining land fill area will be seeded and the temporary sediment basins will be leveled off and seeded.

The grade stabilization structure will stabilize the mouth of the existing drainage outlet for this site, preventing down cutting in the drainage channel.

The total cost for the management program at this site is approximately $102,000 (November 1979 price levels).

Site 40-3. This 32 acre site is a former sand and gravel pit. The past gravel pit operations prevented the establishment of a permanent vegetative cover. This has made the existing soil surface very vulnerable to the erosive force of the raindrop and resultant runoff and gullies have developed (see Photo 15).

The management program developed to control gully erosion at this site includes (see Table 47, page 88): 32 acres of critical area stabilization; 32 acres of site grading; and one temporary sediment basin.

Site grading (32 acres) is required to flatten out the steep slopes (which will prevent the surface runoff from obtaining eroding velocities) and to fill in the existing gullies.

Critical area stabilization (32 acres) will provide a protective ground cover over the soil surface, absorbing the impact energy of the raindrop before it comes in contact with the soil and protecting the soil surface from the erosive force of the resultant runoff. However, due to poor soil conditions at this site, it is anticipated that it will take several years for this vegetative cover to become well established. Therefore, a temporary sediment basin has been included to prevent the sediment, eroded off this site before the vegetation becomes well established, from reaching the Cuyahoga River. After the vegetation has become well established, the temporary sediment basin will no longer be required and will be filled in and seeded.

The total cost for the management program at this site is approximately $141,000 (November 1979 price levels).

The management program developed to control gully erosion at this site includes (see Table 47):

(1) 32 acres of critical area stabilization and site grading;

(2) and one temporary sediment basin.

Site grading is required to flatten the steep slopes of the gravel pit (which will prevent the surface runoff from obtaining eroding velocities) and to prepare the area for critical area stabilization.

Critical area stabilization will provide a protective ground cover over the soil surface, absorbing the impact energy of the raindrop before it comes in contact with the soil and protecting the soil surface from the erosive force of the resultant runoff. However, due to poor soil conditions, it is anticipated that a dense vegetative growth will take two to three years to become fully established.

Therefore, a temporary sediment basin has been included in the management plan to prevent the sediment eroding off the site from entering the river system during this initial two to three year period. Once the vegetation becomes fully established, the termporary sediment basin will no longer be required and will be leveled off and seeded. The total cost for the management program at this site is approximately $141,000 (November 1979 price levels).

As previously discussed, management programs for the remaining sites are presented in Tables 16 through 47.

Table 16 - Recommended Management Program for Site 14-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	18	5,400	3	162
Site Grading	Acres	3,000	18	54,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		11,880	-	-
Subtotal	-	-		71,280	-	162
Engineering and Design (10 percent)	-	-		7,128	-	-
Total	-	-		78,408	0	162

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 17 - Recommended Management Program for Site 15-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	12	3,600	3	108
Site Grading	Acres	3,000	5	15,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000	1	2,000	1	20
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		4,120	-	-
Subtotal	-	-		24,720	-	128
Engineering and Design (10 percent)	-	-		2,472	-	
Total	-	-		27,192	0	128

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 18 - Recommended Management Program for Site 15-2 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	-uantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	19	5,700	3	171
Site Grading	Acres	3,000			0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure		2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		1,140	-	-
Subtotal	-	-		6,840	-	171
Engineering and Design (10 percent)	-	-		684	-	-
Total	-	-		7,524	0	171

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 19 - Recommended Management Program for Site 15-3 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$	$	$
Critical Area Stabilization	Acres	300	29	8,700	3	261
Site Grading	Acres	3,000	27	81,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		17,940	-	-
Subtotal	-	-		107,640	-	261
Engineering and Design (10 percent)	-	-		10,764	-	-
Total	-	-		118,404	0	261

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 20 - Recommended Management Program for Site 15-4 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	3	900	3	27
Site Grading	Acres	3,000	3	9,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000	1	2,000	1	20
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		2,380	-	-
Subtotal	-	-		14,280	-	47
Engineering and Design (10 percent)	-	-		1,428	-	-
Total	-	-		15,708	0	47

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 21 - Recommended Management Program for Site 16-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$	$	$
Critical Area Stabilization	Acres	300	50	15,000	3	450
Site Grading	Acres	3,000	50	150,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		33,000	-	-
Subtotal	-	-		198,000	-	450
Engineering and Design (10 percent)	-	-		19,800	-	-
Total	-	-		217,800	0	450

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 22 - Recommended Management Program for Site 17-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$	$	$
Critical Area Stabilization	Acres	300	1	300	3	9
Site Grading	Acres	3,000	1	3,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		660	-	9
Subtotal	-	-		3,960	-	9
Engineering & Design (10 percent)	-	-		396	-	-
Total	-	-		4,356	0	9

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 23 - Recommended Management Program for Site 17-2 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	6	1,800	3	54
Site Grading	Acres	3,000	6	18,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000	1	2,000	1	20
Subsurface Drainage (2)	Feet	1.50	1,000	1,500	1	15
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		4,660	-	-
Subtotal	-	-		27,960	-	89
Engineering & Design (10 percent)	-	-		2,796	-	-
Total	-	-		30,756	0	89

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 24 - Recommended Management Program for Site 18-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	25	7,500	3	225
Site Grading	Acres	3,000	10	30,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000	1	2,000	1	20
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		7,900	-	-
Subtotal	-	-		47,400	-	245
Engineering & Design (10 percent)	-	-		4,740	-	-
Total	-	-		52,140	0	245

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 25 - Recommended Management Program for Site 18-3 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	4	1,200	3	36
Site Grading	Acres	3,000	4	12,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		2,640	-	
Subtotal	-	-		15,840	-	36
Engineering & Design (10 percent)	-	-		1,584	-	-
Total	-	-		17,424	0	36

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 26 - Recommended Management Program for Site 21-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	5	1,500	3	45
Site Grading	Acres	3,000	2	6,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		1,500	-	-
Subtotal	-	-		9,000	-	45
Engineering & Design (10 percent)	-	-		900	-	-
Total	-	-		9,900	0	45

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 27 - Recommended Management Program for Site 24-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	36	10,800	3	324
Site Grading	Acres	3,000	10	30,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		8,160	-	-
Subtotal	-	-		48,960	-	324
Engineering & Design (10 percent)	-	-		4,896	-	-
Total	-	-		53,856	0	324

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 28 - Recommended Management Program for Site 25-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	60	18,000	3	540
Site Grading	Acres	3,000			0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20%)	L.S.	-		3,600	-	-
Subtotal	-	-		21,600	-	540
Engineering & Design (10%)	-	-		2,160	-	-
Total	-	-		23,760	0	540

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 29 - Recommended Management Program for Site 25-2 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$	$	$
Critical Area Stabilization	Acres	300	46	13,800	3	414
Site Grading	Acres	3,000	20	60,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		14,760	-	-
Subtotal	-	-		88,560	-	414
Engineering & Design (10 percent)	-	-		8,856	-	-
Total	-	-		97,400	0	414

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 30 - Recommended Management Program for Site 25-3 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	13	3,900	3	117
Site Grading	Acres	3,000	13	39,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		8,580	-	-
Subtotal	-	-		51,480	-	72
Engineering & Design (10 percent)	-	-		5,148	-	-
Total	-	-		56,628	0	117

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 31 - Recommended Management Program for Site 26-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	1	300	3	9
Site Grading	Acres	3,000	1	3,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		660	-	-
Subtotal	-	-		3,960	-	9
Engineering & Design (10 percent)	-	-		396	-	-
Total	-	-		4,356	0	9

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 32 - Recommended Management Program for Site 26-2 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	30	9,000	3	270
Site Grading	Acres	3,000			0	0
Runoff Diversion	Feet	2	12,000	24,000	5	0 2/
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		6,600	-	-
Subtotal	-	-		39,600	-	270
Engineering & Design (10 percent)	-	-		3,960	-	-
Total	-	-		43,560	0	270

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

2/ Temporary runoff diversions to be removed within 1 year. Therefore, O&M cost is not applied at this site. Cost for removal of runoff diversions is included in unit cost.

Table 33 - Recommended Management Program for Site 26-3 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$			$	$
Critical Area Stabilization	Acres	300	2	600	3	18
Site Grading	Acres	3,000			0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		120	-	-
Subtotal	-	-		720	-	18
Engineering & Design (10 percent)	-	-		72	-	-
Total	-	-		792	0	18

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 34 - Recommended Management Program for Site 27-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	4	1,200	3	36
Site Grading	Acres	3,000			0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		240	-	-
Subtotal	-	-		1,440	-	36
Engineering & Design (10 percent)	-	-		144	-	-
Total	-	-		1,584	0	36

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 35 - Recommended Management Program for Site 27-2 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	40	12,000	3	360
Site Grading	Acres	3,000	40	120,000	0	0
Runoff Diversion	Feet	1	5,500	5,500	5	275
Grassed Waterway	Acres	500	2	1,000	3	30
Grade Stabilization Structure	Each	2,000	12	24,000	1	240
Subsurface Drainage	Feet	1.50	2,000	3,000	1	30
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		33,100	-	-
Subtotal	-	-		198,600	-	935
Engineering & Design (10 percent)	-	-		19,860	-	-
Total	-	-		218,460	0	935

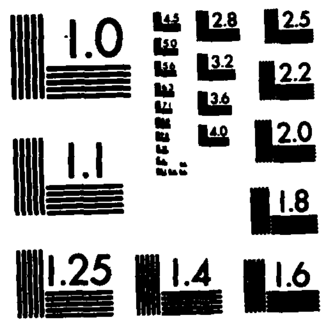
1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

AD-A123 767 CUYAHOGA RIVER OHIO RESTORATION STUDY THIRD INTERIM PRELIMINARY FEASIBILI..(U) CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT R AGUGLIA ET AL. JUN 82

2/2

UNCLASSIFIED F/G 13/2 NL

END
DATE
FILMED
8.3
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Table 36 - Recommended Management Program for Site 27-3 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	5	1,500	3	45
Site Grading	Acres	3,000			0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000	1	2,000	1	20
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		700	-	-
Subtotal	-	-		4,200	-	65
Engineering & Design (10 percent)	-	-		420	-	-
Total	-	-		4,620	0	65

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 37 - Recommended Management Program for Site 27-4 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	7	2,100	3	63
Site Grading	Acres	3,000	7	21,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000	1	2,000	1	20
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		5,020	-	-
Subtotal	-	-		30,120	-	83
Engineering & Design (10 percent)	-	-		3,012	-	-
Total	-	-		33,132	0	83

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 38 - Recommended Management Program for Site 27-5 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	2	600	3	18
Site Grading	Acres	3,000	2	6,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000	1	2,000	1	20
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		1,720	-	-
Subtotal	-	-		10,320	-	38
Engineering & Design (10 percent)	-	-		1,032	-	-
Total	-	-		11,352	0	38

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 39 - Recommended Management Program for Site 28-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	28	8,400	3	252
Site Grading	Acres	3,000	28	84,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000	3	6,000	1	60
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		19,680	-	-
Subtotal	-	-		118,080	-	312
Engineering & Design (10 percent)	-	-		11,808	-	-
Total	-	-		129,888	0	312

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 40 - Recommended Management Program for Site 31-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	6	1,800	3	54
Site Grading	Acres	3,000	6	18,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		3,960	-	-
Subtotal	-	-		23,760	-	54
Engineering & Design (10 percent)	-	-		2,376	-	-
Total	-	-		26,136	0	54

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 41 - Recommended Management Program for Site 33-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	80	2,400	3	72
Site Grading	Acres	3,000	8	24,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		5,280	-	-
Subtotal	-	-		31,680	-	72
Engineering & Design (10 percent)	-	-		3,168	-	-
Total	-	-		34,848	0	72

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 42 - Recommended Management Program for Site 34-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	40	12,000	3	72
Site Grading	Acres	3,000	10	30,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		8,400	-	-
Subtotal	-	-		50,400	-	72
Engineering & Design (10 percent)	-	-		5,040	-	-
Total	-	-		55,440	0	72

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 43 - Recommended Management Program for Site 34-2 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	4	1,200	3	36
Site Grading	Acres	3,000			0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		240	-	-
Subtotal	-	-		1,440	-	36
Engineering & Design (10 percent)	-	-		144	-	-
Total	-	-		1,584	0	36

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 44 - Recommended Management Program for Site 36-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$	$	$
Critical Area Stabilization	Acres	300	3	900	3	27
Site Grading	Acres	3,000			0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		180	-	-
Subtotal	-	-		1,080	-	27
Engineering & Design (10 percent)	-	-		108	-	-
Total	-	-		1,188	0	27

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 45 - Recommended Management Program for Site 36-2 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization	Acres	300	3	900	3	27
Site Grading	Acres	3,000	3	9,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin	Each	1,000			5	
Contingencies (20 percent)	L.S.	-		1,980	-	-
Subtotal	-	-		11,880	-	27
Engineering & Design (10 percent)	-	-		1,188	-	-
Total	-	-		13,086	0	27

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

Table 46 - Recommended Management Program for Site 38-1 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization 2/	Acres	300	45	13,500	3	405
Site Grading	Acres	3,000	20	60,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000	1	2,000	1	2(
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin 3/	*Each*	1,000	2	2,000	5	100
Contingencies (20 percent)	L.S.	-		15,500	-	-
Subtotal	-	-		93,000	-	525
Engineering & Design (10 percent)	-	-		9,300	-	-
Total	-	-		102,300	0	525

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

2/ Due to ongoing land fill operations, the total site cannot be initially stabilized. As land fill operations are completed on portions of this site, these areas will be stabilized. This process will continue until the total site is stabilized.

3/ Temporary sediment basins required to prevent sediment eroding off areas in active use from entering the river system. Once these active use areas are stabilized, these temporary sediment basins will be leveled off and seeded.

Table 47 - Recommended Management Program for Site 40-3 - Estimate of First Cost and Annual Operation and Maintenance Cost

Required Best Management Practices	Unit	Unit Cost 1/	Quantity	Initial Installation Cost	Annual O&M Percent of Installation Cost	Annual O&M Cost
		$		$		$
Critical Area Stabilization 2/	Acres	300	32	9,600	3	288
Site Grading	Acres	3,000	32	96,000	0	0
Runoff Diversion	Feet	1			5	
Grassed Waterway	Acres	500			3	
Grade Stabilization Structure	Each	2,000			1	
Subsurface Drainage	Feet	1.50			1	
					5	
					3	
Sediment Basin 3/	Each	1,000	1 2/	1,000	5	50
Contingencies (20 percent)	L.S.	-		21,320	-	-
Subtotal	-	-		127,920	-	338
Engineering & Design (10 percent)	-	-		12,792	-	-
Total	-	-		140,712	0	338

1/ Unit costs are based on SCS experience with similar work in the area and are on November 1979 price levels.

2/ Temporary sediment basins required until vegetation becomes well established. Delay in establishing vegetation is due to poor soil conditions which will inhibit vegetation growth.

b. Summary and General Conclusions. This study identified a total of 32 sites, comprising 587 acres, where gully erosion or flood plain scour is occurring within the study area. The location of these sites are shown on Plates 9 and 10. The study also indicated that these sites produce about 138,000 tons of sediment per year that requires annual maintenance dredging at Cleveland Harbor (11 percent of the total volume dredged). These sites also produce an additional 48,000 tons of sediment per year from gully erosion that does not enter the river system. However, this still represents a significant loss of a natural resource.

Management programs were developed to control the erosion that is occurring at each site. These management programs consist of various combinations of Best Management Practices (BMP's) and vary from site to site. Two BMP's critical area stabilization and site grading are the main components of each management program. Site grading is required to fill in the existing gullies, to flatten out the slope (which will prevent the overland flow from obtaining erosive velocities) and to prepare the area for seeding. Critical area stabilization is required to provide a protective ground cover. This cover will absorb the impact energy of the raindrop before it comes in contact with the soil and protects the soil surface from the erosive force of the resultant runoff.

As shown on Table 48, the total initial construction cost to treat these 32 sites is about $1,634,000, or, $2,800 per acre. This cost per acre is significantly higher than the average $300 per acre cost to treat the upland area for critical sheet and rill erosion. This is because of the high cost for site grading which is required for these 32 sites but is not required for areas having critical sheet and rill erosion.

In addition to the benefits that would be realized for reduced harbor dredging, other benefits of sediment control would be realized if these management programs are implemented. These are:

(1) preservation of the land for sustained use without deterioration;

(2) conservation of a natural resource; and

(3) improving vegetative cover.

These benefits are deemed adequate to justify the total cost of stabilizing these areas independently of the reduced dredging costs.

Table 48 - Summary of Recommended Management Programs for Identifiable Nonpoint Sources of Erosion: F [illegible]imated First Cost and Annual Operation and Maintenance Cost

Site Number 1/	Size (acres)	First Cost of Construction 2/ $	Annual Operation and Maintenance Cost 2/ $
14-1	18	78,408	162
15-1	12	27,192	128
15-2	19	7,524	171
15-3	29	118,404	261
16-4	3	15,708	47
16-1	50	217,800	450
17-1	1	4,356	9
17-2	6	30,756	89
18-1	25	52,140	245
18-3	4	17,424	36
21-1	5	9,900	45
24-1	36	53,856	324
25-1	60	23,760	540
25-2	46	97,416	414
25-3	13	56,628	117
26-1	1	4,356	9
26-2	30	43,560	270
26-3	2	792	18
27-1	4	1,584	36
27-2	40	218,460	935

Table 48 - Summary of Recommended Management Programs for Identifiable Nonpoint Sources of Erosion: Estimated First Cost and Annual Operation and Maintenance Cost (Cont'd)

Site Number 1/	Size	First Cost of Construction 2/	Annual Operation and Maintenance Cost 2/
	(acres)	$	$
27-2	40	218,460	935
27-3	5	4,620	65
27-4	7	33,132	83
27-5	2	11,352	38
28-1	28	129,888	312
31-1	6	26,136	54
33-1	8	34,848	72
34-1	40	55,440	360
34-2	4	1,584	36
36-1	3	1,188	27
36-2	3	13,086	27
38-1	45	102,300	525
40-3	32	140,712	338
Total	587	1,634,310	6,243
		Say 1,634,000 3/	Say 6,200

1/ See Plates 9 and 10 for location of each site.
2/ November 1979 price levels.
3/ Average cost per acre for erosion control is $2,800.

SECTION IV

SUMMARY AND GENERAL CONCLUSIONS

GENERAL

The purpose of this Supplemental Report and the Preliminary Feasibility Report (PFR) was to present a summary of the results of the planning effort conducted since initiation of the erosion and sedimentation study. This planning effort included detailed studies to identify and quantify the major sources of sediment in the Cuyahoga River watershed, and formulation and assessment of a wide range of alternative measures for addressing the erosion and sedimentation problems of the area.

The harbor at Cleveland, OH, consists of a breakwater protected Lakefront Harbor in Lake Erie and improved navigation channels on the Cuyahoga River and Old River. When sediment carried by the Cuyahoga River reaches the relatively quiet waters of the navigation channel and Lakefront Harbor, it deposits sediments and forms shoals. These shoals must then be removed by maintenance dredging costing approximately $4,000,000 per year. (NOTE: Does not include additional cost of providing diked disposal facilities required because the dredged sediment is heavily polluted based on present U.S. Environmental Protection Agency standards.) Also, in addition to the annual cost for dredging the navigation channels and Lakefront Harbor, sediment accumulation presents severe problems to commercial interests utilizing the harbor facilities. Since dredging is normally not concluded until July, vessels must reduce their load in the Lakefront Harbor before proceeding upriver; also, sediment enters the ship's ballast system and accumulates until the ship is laid up.

Although the Cuyahoga River drains an area of approximately 810 square miles, the scope of this study was directed towards identifying the sources of erosion and determining the feasibility of providing erosion control measures in the 303 square-miles of the Cuyahoga River Basin between Independence, OH, (river mile 13.8) and Old Portage, OH, (river mile 40.25). This reach of the river was identified by Dr. Robert Apman in his report on "Erosion and Sedimentation of the Cuyahoga River Basin" (1973) as the most prolific source of sediment in the river system. Dr. Apmann's findings were subsequently confirmed by a 1-year suspended sediment data collecting program conducted by the U.S. Geological Survey.

A summary of the results of the erosion and sedimentation studies follows.

SUMMARY RESULTS OF STREAMBANK EROSION CONTROL STUDIES

The purposes of the streambank erosion control studies conducted for this study were to identify and quantify sources of streambank erosion and to determine the feasibility of implementing streambank erosion control measures in the channel component study area. The channel component study area consisted of the main stem (main channel) of the Cuyahoga River between Independence, OH, (river mile 13.8) and Old Portage (river mile 40.25) and the channels of the six major tributaries in this reach. These tributaries are Mud Brook, Brandywine Creek, and Tinkers Creek on the east side of the basin and Yellow Creek, Furnace Run and Chippewa Creek on the west side of the basin.

Results of the studies (see the PFR) conducted indicated that of the 143 miles of streambanks studied (71.5 river/stream miles) only 22.7 miles, or 16 percent of the streambanks were actively eroding. The studies also indicated that annual streambank erosion annually produces about 52,000 cubic yards of sediment. Of this 52,000 cubic yards of sediment, it is estimated that 47,000 cubic yards of sediment is transported to Cleveland Harbor and requires annual maintenance dredging. This volume of sediment represents about 5 percent of the total volume of sediment annually dredged. The studies also indicated that there were seven locations on the Cuyahoga River where the existing rate of annual streambank erosion was likely to produce a change in the course of the river (potential meander change). If these potential meander changes were to occur, they would introduce an additional 125,000 cubic yards of sediment into the river system. In addition, the studies indicated that damage to local roads and railroad facilities of the Baltimore and Ohio Railroad will occur in the future due to streambank erosion at these sites.

Initially a total of nine structural and/or nonstructural conceptual alternatives (including no action) were formulated to control streambank erosion within the study area. Preliminary evaluation and assessment of these conceptual alternatives indicated that only three alternatives warranted further consideration. In addition, the basis of comparison for these three alternatives was the no action (do nothing) plan. Based on additional evaluation and assessment, it was determined that the three alternatives warranting further study were not economically feasible and no overriding environmental or social benefits would be derived from implementation of these plans. Therefore, it was concluded that the "no action" plan was the appropriate course of action as regards streambank erosion control for the Cuyahoga River and its tributaries. In addition, it was concluded that the Third Interim Study on Erosion and Sedimentation should be terminated.

SUMMARY RESULTS OF UPLAND EROSION CONTROLS STUDIES

The purposes of the upland erosion control studies conducted for this study were to identify and quantify sources of upland erosion and to develop a series of management programs to control erosion in the upland study area (the 303 square-mile drainage basin of the Cuyahoga River between Independence (river mile 13.8) and Old Portage (river mile 40.25)).

Implementation of these management programs, must, however, be pursued by other (local) interests.

Results of the investigations conducted for this study show that erosion and sedimentation is a very serious problem in the upland area. For example, sheet and rill erosion (diffuse nonpoint sources) from critically eroding areas in the seven subwatersheds produce about 884,000 tons of soil loss annually. These critically eroding areas occur on only 27,000 acres, or 14 percent of the total area. All other areas within the seven subwatersheds produce an insignificant volume of soil loss and can be deleted from further consideration.

Of the 884,000 tons of soil loss produced from critically eroding areas in the seven subwatersheds studied, it is estimated that 551,000 tons is delivered to the Cuyahoga River system annually and requires maintenance dredging at Cleveland Harbor. This volume of sediment represents about 43 percent of the total volume of sediment dredged. Therefore, in order to significantly reduce dredging costs at Cleveland Harbor, an effective erosion control program must be implemented on these critically eroding areas.

Management programs were developed to control sheet and rill erosion on critically eroding areas for the seven subwatersheds studied. These management programs consisted of Best Management Practices (BMP's) which, based on Soil Conservation Service experience with similar type projects, are both effective in erosion control and economically justified (that is, local interests implementing the management programs will realize benefits equal to or greater than the cost of implementing these programs). The average cost to implement these management programs on critically eroding areas was estimated at $300 per acre.

Sediment produced from identifiable nonpoint sources of erosion (gully erosion and flood plain scour on disturbed areas) is also a significant problem in the upland area. For example, this study identified a total of 32 sites, comprising 587 acres, where gully erosion or flood plain scour is occurring within the study area. In addition, it is estimated that these sites produce about 138,000 tons of sediment per year that requires annual maintenance dredging at Cleveland Harbor (11 percent of the total volume dredged). These sites also produce an additional 48,000 tons of soil loss per year from gully erosion that does not enter the river system. However, this still represents a significant loss of a natural resource.

Management programs were developed to control the erosion on these 32 identifiable nonpoint sources of erosion. These management programs consisted of BMP's similar to those required to treat sheet and rill erosion. The average cost to implement these management programs was estimated at $2,800 per acre.

SECTION V

RECOMMENDATIONS

The recommendations in this section refer to the entire erosion and sedimentation study, combined PFR, and Supplemental Report.

Since streambank erosion control improvements cannot be economically justified, it is recommended that no further consideration be given to streambank erosion control improvements on the Cuyahoga River Basin and that, therefore, the Third Interim Study on Erosion and Sedimentation be terminated. In addition, it is recommended that local interests implement upland erosion control practices (Best Management Practices) on critically eroding areas in the watershed.

Studies conducted for this report identified sites where damage to local roads and railroad facilities of the Baltimore and Ohio Railroad will occur in the future due to streambank erosion. It is recommended that the affected interests (local governments and the Baltimore and Ohio Railroad) implement streambank erosion control measures at these sites before this damage occurs and service is interrupted. It is noted that, prior to construction of these protective measures, affected interests must make application for a Department of the Army Permit if filling of the waterway or flood plain is proposed.

for Joseph C. Creeden, MAJ
GEORGE P. JOHNSON
Colonel, Corps of Engineers
Commanding

LMED

-8